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ENCYCLOPÆDIA BRITANNICA

SEVENTH EDITION.

THE

ENCYCLOPÆDIA BRITANNICA

OR

DICTIONARY

OF

ARTS, SCIENCES, AND GENERAL LITERATURE.

SEVENTH EDITION,

WITH PRELIMINARY DISSERTATIONS ON THE HISTORY OF THE SCIENCES,

AND

OTHER EXTENSIVE IMPROVEMENTS AND ADDITIONS;

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ENCYCLOPÆDIA BRITANNICA.

COMPARATIVE ANATOMY.

PART I.

ANATOMY OF THE ORGANS OF RELATION.

CHAP. I.—COMPARATIVE OSTEOLOGY.

Comparative Anatomy.

RED-BLOODED ANIMALS only can be said to possess that assemblage of bones denominated skeleton; and as in these the most constant part is the vertebral column, it furnishes the general character of Vertebrated. The shells of the MOLLUSCA and the *Crustacea* have been generally regarded as a species of internal skeleton; and in the circumstance of affording mechanical support and external protection, they indeed resemble the skeleton of the VERTEBRATA. But neither in mode of developement nor in chemical constitution can they be regarded as of the same nature. Hence it is only in the vertebrated classes that it is requisite to study the peculiarities of the skeleton.

Bones generally.

In general characters the bones of the Mammalia resemble those of the human subject. Like them, they are white, firm, elastic, and incompressible. They consist also of compact and reticular or cancellated tissue. In the lower animals the latter kind of structure is in general coarser and looser than in man; and in the CETACEA especially the cavities are large. In the carnivorous animals the compact structure is exceedingly dense, and gives the bone much greater weight than in other animals. In the CETACEA also the acoustic or lithoid portion of the temporal bone is of a marble hardness.

The bones of the Mammalia may, like those of man, be distinguished, according to their mechanical form, into long, flat, and short bones. Though the first class in general possess a medullary canal, this cavity is imperfect or wholly wanting in the bones of the CETACEA and AMPHIBIA.

The cavities denominated *sinuses* are much more completely developed in several of the MAMMALIA than in the human skeleton. In the pig these cavities extend into the occipital bone; in the elephant they not only give the frontal bone extraordinary protuberance, but they extend into the parietal, temporal, and even the occipital bones, and contribute much to augment the volume of the head. In the ox, deer, and sheep, they communicate with the cavity of the horns.

The bones of BIRDS are in general whiter, firmer, and smoother than those of the MAMMALIA; and they consist of a firm, compact substance, which is elastic and hard in the bones of the trunk, and extremely brittle in those of the extremities. With the exception also of some of the thin, flat bones, as the sternum, they consist of thin, compact walls, inclosing large capacious cavities, which contain not marrow, but air, and which communicate by one or more minute holes with the windpipe and lungs. While these cavities, which may be regarded as the most perfect and advanced form of sinuses, diminish considerably the weight of the whole skeleton, by the density and completely cylindrical shape, they rather augment the strength. In the chick, and at birth, the bones are homogeneous and without cavities; afterwards they contain marrow; and eventually this disappears and gives place to air.

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The bones of the REPTILES are not remarkable in any respect, unless in being void in general of medullary cavity. The absence of this canal was originally observed by Caldesi, and afterwards by Cuvier, in the tortoise; by Troja in the bones of the frog and toad; and by Carus in those of the turtle. In the crocodile, however, and in several of the lizard family, they are large and distinct. The bones of Reptiles also are less firm than those of Birds and Mammals.

The bones of FISHES are remarkable for great softness, flexibility, and elasticity. Those of the lamprey, shark, ray or skate, and sturgeon family, are soft, flexible, sectile, of a bluish white colour, translucent, and so elastic that a cutting instrument forced into them is speedily retruded by the resilient nature of the bony matter. From these characters, the bones of these families have been regarded as cartilaginous, and the fishes themselves have been distinguished by this character. (PISCES CARTILAGINEI, PISCES CHONDROPTERYGII.) In the other fishes, the bones, though softer than those of Mammals, Birds, and Reptiles, present a greater degree of firmness and solidity, are whiter and more opaque, and are much less sectile, than those of the cartilaginous division. As in this respect, therefore, they approach the genuine bone of the Mammals, these are distinguished as fishes with osseous skeletons. (PISCES OSSEI.)

The bones of both classes of fishes consist of a large quantity of gelatine, with a small proportion of phosphate

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of lime. In the osseous fishes, however, the latter substance is most abundant.

The colour of the bones of fishes, though in general whitish gray, is observed to vary in certain genera. In the gar-pike (*esox belone*), for instance, they are green, and in the viviparous blenny (*blennius viviparus*), the sand launce (*ammodytes tobianus*), and two species of *labrus* (the *l. lapina* and *æruginosa*), they assume a green colour after boiling. The causes of these varieties in colour are unknown.

SECT. 1.—OSTEOLOGY OF THE MAMMIFEROUS ANIMALS.

Plate XXXIV. fig. 1.

The skeleton of the MAMMALIA bears a general resemblance to that of the human subject, in the construction, shape, and disposition of its component pieces. Distinguished, like that, into head, trunk, and extremities, we recognise the importance of the trunk, and especially of the spine, in the different classes of mammiferous animals.

The spine.

The spine consists of separate vertebræ, which are conveniently distinguished, as in man, into *cervical*, *dorsal* or *costal*, *lumbar*, *sacral*, and *coccygeal* or *caudal*.

Cervical vertebræ.

The number of cervical vertebræ is the same in animals with the longest and shortest necks,—in the horse, camel, and giraffe, and in the mole and ant-eater. They are always seven. The only exception is observed in the *Ai* or three-toed sloth (*bradypus tridactyla*), which has 9 cervical vertebræ (Cuvier); and an apparent exception is presented in the dolphin and porpoise, in which the first two are consolidated into one; and in the cachalot or large-headed whale, in which the last six, sometimes the whole seven, are united or ankylosed. The last six are also united in the ant-eater and manis (Cuvier). Even in this state, however, the traces of the original separation are distinct.

In the ape the cervical vertebræ are distinguished from those of man chiefly by the spinous processes being stronger and not bifid, and in their bodies being projected more over each other before, so as to support the head more perfectly. In the ZOOPHAGA the transverse processes of the cervical vertebræ are flattened from behind backwards, and those of the *atlas* are very large, both for supporting the head and giving attachment to the strong muscles employed in defence, attacking prey, or bearing it off. For the same purpose the spinous process of the *axis* is very prominent, while the others are short and directed towards the head. In the mole and shrew the cervical vertebræ, which are void of spinous processes, are simple osseous rings, which move easily on each other, probably to facilitate the frequent motions requisite in these animals in burrowing. In the hog the cervical transverse processes are compressed and broad before, so as to appear double. In the elephant the cervical vertebræ have short single spinous processes, and the bodies projecting over each other as in the ape. In the Ruminants the length of the spinous processes diminishes as the neck is elongated. Thus they are almost wanting in the camel and giraffe, in which the arched neck is much retro-flected; and the same peculiarity is recognised in those of the horse.

From these facts it results that the length of the neck depends not on the number, but on the longitudinal extent, of the cervical vertebræ.

Dorsal vertebræ.

The dorsal, thoracic, or costal vertebræ are distinguished by forming the central fixed basis of the ribs; and their number depends on that of the latter class of bones, which is very variable. The number of costal vertebræ varies from 11, which is that of the Chinese monkey, common bat, armadillo, helmet-headed dolphin (*delphinus globiceps*), and Gangetic dolphin, to 23, which is that of the *Unau* (*Brædypus didactylus*). The most common number is 12, which is that not only of man, but of the ourang-outang, silky monkey (*simia marikina*), patas (*s. patas*), maimon (*simia maimon*), macaca (*simia cynomolgus*), baboon (*s. sphynx*), magot (*s. inuus*), mandrill (*s. maimon*), pongo (*s. pongo*), macauco (*lemur catta*), vampyre, great and horse-shoe bat, colugo (*galeopithecus*), shrew, hare and rabbit, agouti, flying squirrel, mouse and field rat, and camel and dromedary. The next most frequent number is 13, which is that of the mole, white bear, civet, the cat tribe (*felis*), the dog, wolf and fox, the *didelphis* tribe, the cavy, guinea pig and paca, the mouse tribe, excluding the two exceptions already mentioned, the long-tailed *manis*, the stag, the antelope genus, the goat, sheep, and ox, and the dolphin and porpoise. The number is 14 in the gibbon, coaïta, and weeping monkey, in the howling ape (*simia beelzebul*), the *tarsius*, the brown bear, raccoon and coati, the weazel *genus*, the porcupine, hog, and giraffe. It is 15 in the lori, hedgehog and tenrec, in the badger, pangolin, and seal. The number is 16 in the glutton, hyena, ant-eater, American lamantin, and *megatherium*. In the horse, quagga, and dugong, they are 18; in the rhinoceros 19; in the Indian elephant and tapir 20; and in the *Unau* or two-toed sloth 23, which, as already stated, is the greatest number yet known.

In the ape family the dorsal vertebræ resemble those of the human subject, but their spinous processes are long, and erect in the macaca and magot. In the bats, instead of spinous processes, which are wanting, there are minute tubercles. The want of these, however, in sundry species, leaves the column comparatively smooth behind. In the proper quadrupeds these processes are larger, straighter, and stronger, as the head is weighty or supported on a long neck, in order to give attachment to the strong yellow cervical ligament. This peculiarity is very distinct in the giraffe, camel, ox, rhinoceros, and elephant. In the dolphin they are straight, and smaller than those of the loins.

Lumbar vertebræ.

The lumbar vertebræ vary in number still more, perhaps, than the cervical and dorsal; and this variety may occasionally be traced to the greater or less distinctness with which the sacral and coccygeal are distinguished. The smallest number is 2, which is that of the two-toed ant-eater, *ornithorhyncus*, and American lamantin; and the greatest 9, which is that of the lori. The most frequent number is 7, which is that of the greater part of the monkeys, the macauco, the great bat (*noctula*), the hedgehog, shrew, raccoon; the tiger, panther, puma, and cat, in the feline *genus;* the wolf and fox in the dog; the hare and rabbit; the whole murine *genus* except the hamster; and in the camel and dromedary. The next number in frequency is 6, which is that of the horse-shoe bat, the colugo (*galeopithecus*), the white and brown bear, the coati, the weasel genus, the civet, the lion, among the feline, and the dog among the canine genus, the didelphis and cavy *genera*, the hamster, the stag, antelope, goat, sheep, ox, horse, and quagga. The gibbon, coaïta, *Ai*, *Echidna* or *Ornithorhyncus hystrix* of English zoologists, six-banded armadillo, and dugong, have only 3 lumbar vertebræ; the ourang-outang, pongo, and howling ape, 4; the vampyre bat 4; the hyena, armadillo, *Unau*, and tapir, 4; the jocko, tarsier, and common bat, 5; the badger and glutton, the porcupine, beaver, pangolin, long-tailed manis, hog, giraffe, gazelle, chamois, and seal, all 5; and the agouti and flying squirrel have 8.

In the QUADRUMANA and ZOOPHAGA generally the outer side of each posterior articular process presents an apex turned backward, so that the anterior articular process of the next vertebra is locked between two eminences, which confine its movement much. Though this apex is found

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in the RODENTIA, it is there shorter; and the arrangement is wanting in the other tribes. The size of the transverse processes indicates the strength of the loins,—a fact which is evinced especially in the instance of the horse, porpoise, &c.

Sacral vertebræ.

The number of sacral vertebræ is still more various, even in the species of the same genus. Thus, while in several of the ape *genus*, in the lori, in the vampyre bat, the colugo (*galeopithecus*), the coati, and two of the didelphis, there is one sacral vertebra only, most of the apes have *sacra* consisting of 2, 3, 4, 5, or 6 pieces; the majority of other animals have 3 sacral vertebræ; the hedgehog, porcupine, guinea pig, paca, hare, tiger, several of the murine genus, the ant-eater, rhinoceros, camel, dromedary, chamois, goat, sheep, and ox, have 4; the elephant has 5; the *Ai* 6; the *Unau* 7; and in the mole, white bear, and quagga, they also amount to 7. The frequency of the three sacral vertebræ in the lower animals shows that Galen, who ascribes only 3 to the human subject, must have derived this inference from the former.

These vertebræ are in the mammalia narrower than in man, and their direction forms with the spine, instead of receding backwards, a straight line; an arrangement evidently connected with the horizontal position of the former. The shape of the sacrum in the lower mammals is that of an elongated triangle; and it is further remarkable, that in those species which occasionally assume the erect attitude on the hind leg, as apes, bears, and sloths, the width of the sacrum is proportionally greater. The sacral spines, which are short in man and the ape, become longer in the ZOOPHAGA, and form a continuous ridge in the rhinoceros, most ruminants, and especially in the mole. In the vampyre bat the sacrum forms a long compressed cone, the extremity of which is united to the ischial tuberosities, without sustaining a coccyx. The seal has two sacral bones; but the CETACEA, *e. g.* the dolphin and porpoise, are void both of sacrum and coccyx.

Coccygeal or caudal vertebræ.

The coccygeal bones constitute the tail of the lower animals, and in many instances they are extremely numerous. The smallest number is 3, which is that of the magot (*simia sylvanus, pithecus, et inuus*) or Barbary ape; and the greatest yet known is that of the ant-eater, in which they amount to 40, and the long-tailed manis, in which they amount to 45. Next to these may be placed that of the coaïta 32, the baboon 31, the phalanger (*didelphis orientalis*) 30, the marmoset (*didelphis murina*) 29, the pangolin 28, the silky monkey (*simia rosalia*) and black rat 26, the weeping monkey and howling ape 25; the panther, mouse, dormouse, and elephant, 24; the lion, beaver, water-rat, Norway rat, and field-rat, 23; the flying-cat, puma, cat, dog, marmot, and rhinoceros, 22; the otter, 21; the Chinese monkey, raccoon, civet, hare, and rabbit, 20; the tiger and wolf, 19; the macauco, glutton, marten, fat dormouse, dromedary, giraffe, and quagga, 18; the tarsier, shrew, camel, and horse, 17; and other genera and species, without any determinate order, descending so low as to 9, 8, 7, 6, and 4. The quilled duckbill (*echidna, ornithorhyncus hystrix*) has only 12 caudal vertebræ, while the common one (*ornithorhyncus paradoxus*) has at least 20. The gibbon and vampyre bat are the only mammiferous animals, excepting the CETACEA, in which there are no coccygeal bones. It sometimes happens that a monkey or opossum loses a portion of its tail, when the truncated end is converted into a knotty excrescence, sometimes carious, always different from the taper point of the last coccygeal vertebra; and in this case it is difficult to determine the exact species.

In the CETACEA, in which the absence of *pelvis* affords no mark to distinguish the lower vertebræ into lumbar, sacral, and coccygeal, those below the dorsal may be regarded as *lumbo-coccygeal;* and their number is estimated by deducting that of the cervical and costal from the total number. The following table, which shows the number of the costal, the lumbo-coccygeal, and the total number of vertebræ, indicates that their number varies much in various *genera* of this family.

	d.	l.c.	t.		d.	l.c.	t.
Lamantin	16	24	46	Porpoise	13	40	60
Dugong	18	28	46	Narwal	12	35	54
Dolphin	13	47	67	Hyperoodon	9	29	45
Tursio	13	38	58	Cachalot or White Whale	14–15	39	60
D. Globiceps	11	37	56	Greenland Whale	15	37	59
D. Griseus	12	42	61	Rorquhal	14	31	52
D. Gangeticus	11	28	46				

In general, however, if we reckon the first 2, 3, or 5 vertebræ after the costal as lumbar, it may be said that the caudal vertebræ of the CETACEA vary from 22 or 25, which are the numbers respectively in the lamantin and dugong, to 34, 38, and 42, at which they may be estimated in the dolphin. We shall see that, in the dugong at least, we are guided in this estimate by the rudimental bones of the pelvis.

The coccygeal or caudal vertebræ of the MAMMALIA may be distinguished into two kinds; those which contain a canal in continuity with that of the vertebral column and sacrum, and those in which the pieces are solid. The first, which are next the sacrum, have articular, transverse, and spinous processes, distinct in proportion as the animals move their tails. The latter are generally prismatic in shape, diminish in size towards the extremity, and have only slight tubercles for muscular attachments. Animals with prehensile tails, as the American ape (*sapajous*), have above, at the base of the body of each vertebra, two small tubercles, between which pass the tendons of the flexor muscles. By means of this mechanism these animals can twine the tail round the branch of a tree with sufficient force to support the weight of the body.

The MAMMALIA with long mobile tails have often two or three small supernumerary bones placed on the lower surface of the junctions of several of the coccygeal vertebræ, from the 3d or 4th to the 7th or 8th. These sesamoid bones give attachment to muscles. In the beaver, which employs its tail as a trowel, the transverse processes are remarkable for size, while the lower spinous processes are larger than the upper ones,—an arrangement which enables it to depress the tail forcibly when it beats the ground.

The chest.

The shape of the chest in the MAMMALIA varies in general as the clavicles are present or wanting. In animals provided with clavicles, as the QUADRUMANA, bats, the squirrel, beaver, mole, ant-eater, hedgehog, and sloth, the shape of the chest approaches to the human, or is conoidal, and flattened before and behind. In those void of clavicles it is compressed laterally, from the smaller incurvation of the ribs; and the sternum makes a remarkable prominence, so that the transverse or intercostal diameter is less proportionally, and the sterno-vertebral is greater proportionally, than in man and the claviculated animals. In the long-legged animals, as the giraffe and those of the stag kind, this prominence of the sternum is sufficient to give it a keel-like appearance (*thorax carinatus*). In the carnivorous animals the chest presents its greatest longitudinal extent.

The sternum.

The ribs.

The number and shape of the ribs varies in the different tribes. In number, indeed, the ribs always correspond with that of the costal vertebræ. Thus, in the QUADRUMANA, ZOOPHAGA, RODENTIA, EDENTATA, and RUMINANTIA, they vary from 12 to 15 pair, with only three exceptions, the glutton, hyena, and ant-eater. In the Chinese monkey, common bat, and armadillo, they are a pair less than in

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man. While the quilled duckbill (*echidna, ornithorhyncus hystrix*) has only 15 ribs, the common duckbill (*ornithorhyncus paradoxus*) has 17; the horse and quagga have 18, the rhinoceros 19, the elephant and tapir 20, and in the *Unau* or two-toed sloth they amount to 23, which is the greatest known number. On the whole, the most prevalent number is 13. In the carnivorous animals they are narrow and dense in structure. In the herbivorous they are large, broad, and thick. In the armadillo the two first ribs are large compared with the others. In the two-toed ant-eater, which has 16 pairs, they are so broad that they are imbricated over each other like the plates of a corslet, and render the parietes of this animal's chest exceedingly solid. In the two species of duckbill (*ornithorhyncus paradoxus* and *hystrix; echidna* of Cuvier), the true ribs, in number 6, consist of two portions—a long or vertebral joined to the spine, and a short or sternal attached to the sternum. These portions are united by cartilage, so as to resemble the ribs of birds. The 9 or 10 false ribs terminate before in broad, flat, oval plates of bone, which are mutually connected by elastic ligaments.

The sternum, which is broad in the ourang and pongo, is narrow in the other species of ape, and consists of seven or eight pieces. In the vampyre and all the bat family it is narrow, but presents before or below rather a prominent azygous ridge or keel (*carina*), and an anterior extremity, broad on the sides, like a T, for receiving the clavicles. In the mole the clavicular extremity of the *sternum* is continued before the ribs, and is flat on the sides for receiving the two short clavicles. In the hog the sternum is broad behind and narrow before. In the rhinoceros, horse, and elephant, it is prolonged before and flat on the sides. In the CETACEA it is broad and thin, especially before.

Cranium.

Though the QUADRUMANA have 8 cranial bones, the sphenoid often consists of two portions, one forming the orbitar wings and the anterior clinoid processes, the other the temporal or large wings, the posterior clinoid processes, and the basilar fossa. The two parietal bones are early united into one in the CHIROPTERA and the other ZOOPHAGA, in which, however, the frontal remains bipartcd by a middle suture. The temporal tympanum is separated from the rest of the bone by a suture, which is seldom obliterated in the feline, canine, and *viverra* genera. The temporal tympanum is also separate in the RODENTIA, and the frontal ununited. The parietal is united in some, as the hare, the porcupine, *cabia*, marmot, rat, and squirrel; separate in the mouse, fat dormouse, and rabbit. The frontal and parietal bones of the elephant are early united with the other cranial bones, and form a vault without trace of suture. In the hog, tapir, and *hippopotamus*, the two parietal bones form one piece, while the frontal bone is biparted; and though in the rhinoceros both are biparted, the frontal is early united into one portion. The sphenoid bone of the animals of this tribe long consists of two pieces, one forming the orbitar wing; the other the temporal wings, which, it is to be further observed, are the smallest, in opposition to their proportional dimensions in man. In the Ruminants and SOLIDUNGULA the frontal remains long parted by its middle suture; but the two parietals are represented by a single bony vault. The tympanum is always distinct from the temporal bone. In the seal and walrus the parietal and the frontal consist of two pieces. The lamantin has only one bony arch, representing the two parietal and the squamous part of the temporal bones, while the temporal tympanum is detached from the rest of the bone. In the other CETACEA the parietal bones are at an early period united to the occipital and temporal bones, so that the five form one solid portion. The auditory or pyramidal bone is always detached from the temporal, and adheres to the cranium by soft parts only. The sphenoid is not only long separate, but consists of several portions.

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Though, among the QUADRUMANA, the cranium of the ourang-outang approaches that of man in shape, it differs nevertheless in the connections of the constituent bones. The temporal wing of the sphenoid bone is very narrow, does not reach the parietal, and touches the frontal only by its upper extremity, so that the temporal bone is partly articulated with the frontal. The temporal suture is not imbricated, but serrated. The same mode of connection is observed in the mandrill, macaca (*s. cynocephalus*), magot, and guenon (*Cercopithecus*), or tailed monkey tribe. In the American monkey the temporal wing of the sphenoid touches neither the frontal nor the parietal bones; but the temporal bone is articulated directly with the malar by its flat portion. In the American monkeys the frontal bone does not touch the temporal wing of the sphenoid, and the parietal is articulated to the malar. In the howling ape (*simia beelzebul*) the connections are as in man.

Connections.

The connections of the cranial bones are in the ZOOPHAGA the same as in man. In the RODENTIA the sphenoid is joined to the frontal and temporal, without touching the parietal; and the orbitar and temporal *fossæ* are very small. In the armadillo, pangolin, and sloth, the connections are as in the RODENTIA; but in the ant-eater the parietal bone, continued below the cranium, is united to the sphenoid at the posterior part of the orbito-temporal *fossæ*.

In the elephant, though the cranial bones are at an early period consolidated into one, the auditory is always distinct from the temporal bone. In the hog, tapir, rhinoceros, and hippopotamus, the sphenoid is united to the parietal bone, and its temporal wings occupy a small space only of the orbitar and temporal fossæ. The orbitar wings, though larger, appear small externally. The auditory bone, though distinct, is, however, united by its base to the margin of the auditory canal of the temporal bone. The sphenoid of the ruminants is articulated, as in man, with all the cranial bones; but its orbitar wing, which is extensive, is principally concealed within the cerebral cavity, and covered by the orbital part of the frontal bone. In the CETACEA generally, all the sutures which remain after early life are squamous or imbricated.

The outline of the frontal bone in the ourang-outang is more irregular than in man, and the orbitar arches are less surbased. In the American monkeys its outline is triangular, and terminates in a point towards the vertex. In the others of this family (*Simia*), this bone is almost elliptical, and the orbitar arches are nearly straight; and in the whole family these arches form, as in man, the anterior border of the frontal bone, in consequence of the narrowness of the root of the nose. In the makis it begins to widen, and the eyes become oblique,—a circumstance which gives their frontal bone a rhomboidal shape.

The frontal bone in the ZOOPHAGA, and in all the subsequent MAMMALIA, except the CETACEA, forms an irregular prismatic or cylindrical surface with three faces—a superior, bounded before by the muzzle, behind by the cranial convexity and two lateral, descending into the orbitar and temporal *fossæ* on each side. The hedgehog, mole, shrew, ant-eater, some of the *phocæ*, the morse or walrus, and the rhinoceros, have no proper orbitar arches; and the frontal bone, though broad behind, is contracted and nearly cylindrical between the orbits. In the hippopotamus, the ruminants, and the one-hoofed animals, it enlarges, and forms a vault over each orbit. Lastly, in the CETACEA it is narrow from before backward, resembling a fillet stretched across the cranium, but descends beneath the maxillary bones to form the floor of the orbit.

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The parietal bones of the ourang-outang differ from those of man only in their temporal margin being nearly straight. Those of the ape are narrower, and become more oblique-angled as the cranium is flattened. In the ZOOPHAGA and EDENTATA they are almost rectangular. The single parietal of the RODENTIA is nearly quadrilateral; but it is sometimes flat, sometimes rounded, sometimes surmounted by a crest. Of the single parietal bone of the ruminants, that of the stag, most of the antelope *genus*, the sheep and the goat, is broad, and sends on each side a narrow process into the temporal *fossa* before the occipital arch; in the camel it is narrower, and bears a longitudinal crest; and in the ox and *antilope bubalus* it is placed behind the occipital crest, and resembles a fillet surrounding the back of the head transversely. In the SOLIDUNGULA the single parietal is nearly quadrilateral, and placed before the occipital crest.

The occipital bone.

The occipital bone in the lower mammalia is remarkable for five characters. 1. The proper occipital surface, instead of being oblique or horizontal, and inferior or basilar, becomes vertical and posterior. 2. The plane of the occipital hole forms with that of the orbits an angle constantly diminishing, becomes parallel to the orbitar plane, and at length crosses it above the head. 3. The plane of the occipital condyles, instead of being transverse and horizontal, becomes oblique, and at length vertical. 4. The basilar or cuneiform process is not only horizontal, but forms with the occipital a right angle. And, 5. The mastoid process, which in man and the ape forms part of the temporal, belongs in the other mammalia to the occipital. In the polar bear, however, the mastoid process constitutes part of the temporal bone.

From the 1st, 2d, and 3d characters, it results that the head of quadrupeds is not balanced on the spine, but is suspended by muscles, tendons, and ligaments, especially the strong cervical, which connects the occipital spine to the spinous processes of the cervical and dorsal vertebræ. This ligament, therefore, though feeble and indistinct in man, is strong, particularly in quadrupeds with heavy head or long neck, in order to counteract the disadvantage of the long lever. It is strongest in the elephant, and is almost wholly ossified in the mole—a condition requisite for the burrowing faculty exercised by that animal.

The temporal bone.

The temporal bone is naturally distinguished in the MAMMALIA into two parts; a flat or proper temporal, corresponding to the squamous part of the human temporal bone, and the pyramidal, acoustic, or auditory, corresponding to the pyramidal or lithoid portion of the human subject. The first only, which is proper to the scull, claims attention here. In the ourang-outang and most of the genus *simia* it forms a trapezium with the longest side above, and the height of which varies with that of the scull. In the American apes it is smallest in this direction. In the ZOOPHAGA the proper temporal bone is as in the ape. Being narrow in the RODENTIA behind, it is a little rounded in the short-muzzled EDENTATA, the RUMINANTIA, and PACHYDERMATA.

The ethmoid is, strictly speaking, the olfactory bone, and shall be mentioned under the organs of sense. The sphenoid, among other offices, may be regarded as the essential ophthalmic bone.

The facial bones.

The facial bones of the lower MAMMALIA differ from those of man; first, in the number of separate pieces; and, secondly, in the form and proportional horizontal extent.

Intermaxillary bones.

The difference in number consists in each superior maxillary bone being divided into a maxillary bone proper, and an anterior or labial portion; which being interposed between the proper maxillary, are commonly denominated the intermaxillary (*ossa intermaxillaria*). As it bears also the superior incisors, it is named by Haller the incisive bone (*os incisivum*); but since it is found not only in the ruminants, which, excepting the camel, are void of incisors, but in the EDENTATA and CETACEA, this denomination is less applicable than the former. It may be doubted whether these should be regarded as additional bones, as they are generally represented by zootomists; for they are in truth merely the incisive or anterior portion of the superior maxillary bones. In other respects, the difference between the human and the animal superior maxillary bone is, that in the former each bone is in one piece, in the latter it is in two. Even in the human fœtus the trace of the separation may be recognised; and we have seen it in the human scull some years after birth. Conversely, it is early obliterated in some quadrupeds. Thus, though distinct in the ourang-outang seen by Cuvier, it was not found by Tyson or Daubenton, and is wanting in one preserved in the Hunterian museum. In a young specimen of the jocko also, noticed by Cuvier, no trace of the intermaxillary suture was observed. It appears also to be wanting in the perforated bat, the horse-shoe bat, and the three-toed sloth.

Mutually united on the mesial plane, the intermaxillary bones are united to the maxillary by sutures, which pass from the outer angles of the latter, near the incisive holes, towards the palate, where they intersect. In form and size it varies in the different orders and genera. Small in many of the ZOOPHAGA and the walrus, it is large in the RODENTIA, in the hippopotamus, porpoise, and cachalot, and prominent in the wombat. In the duckbill it consists of two unciform portions, united by a broad intermediate cartilage.

Elongation of the face.

The peculiarity of the animal face consists in the horizontal elongation of the two jaw-bones. In the monkey tribe this elongation is trifling; and all that is remarked is, that the palate and maxillary bones are more elongated in proportion to their height, and that their anterior part, instead of being vertical, is more or less inclined forwards. The degree of this elongation, which differs in different *genera*, may be estimated by the acuteness of the facial angle.

Interorbital region.

The narrowness of the interorbital space is another character of the animal countenance. In the *guenon* and American ape it is a mere *septum;* but in the ourang-outang, magot, and howler, it is larger, by reason of the nasal *fossæ* ascending to this height. From these the face of the ZOOPHAGA is distinguished by the following circumstances. 1. The breadth of the ascending maxillary processes throws the orbits to the sides; 2. these orbitar surfaces form the anterior wall instead of the floor of the orbit; 3. the malar bone is united neither to the frontal nor to the sphenoid bone, and forms only the zygomatic arch and the lower margin of the orbit; 4. the orbit, closed neither behind nor below, communicates freely with the temporal *fossa;* and, 5. the palate bones are much elongated and form a considerable space of the internal wall, to which the ethmoid bone does not contribute. In the RODENTIA the interorbital space is still larger, by reason of the size of the intermaxillary bones throwing the maxillary backwards and to the sides, where they form the inner orbitar wall, in which the palate bones occupy only a small space. The anterior wall is formed by a process of the maxillary, which contributes to form the zygomatic arch, while the malar is suspended in the middle between the process and that of the temporal bone. Very similar is the face of the elephant, except that the height of the *alveoli* from the tusks, thrusting the nose upwards, and shortening its bones, alters entirely the expression of the head of this animal.

In the sloth, in which the face is short in proportion to

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the scull, the malar bone attached to the maxillary only, is not united to the zygomatic process of the temporal. In the long-muzzled EDENTATA, in which the face is conoidal, the maxillary bones extend to the orbits, and are separated by a broad lacrymal bone, while a long palate bone forms the inner wall of these *fossæ*. The zygomatic arch, which is interrupted in the ant-eater and pangolin, is completed in the Cape ant-eater and the armadillo. In the tapir and rhinoceros the maxillary bone passes beneath the orbit; and the nasal bones form a sort of vault, which supports in the first animal the trunk, and in the second the horn.

In the CETACEA the maxillary and intermaxillary bones form a sort of flattened beak, distinguished into four parallel bands, of which the maxillary, which are external, alone bear teeth in three genera, provided with the latter organs. The nasal *fossa* is a vertical opening before the cranium, surrounded before and laterally by the intermaxillary bones. The maxillary ascend in the same manner, and cover that part of the frontal bone which forms the orbitar vault, but do not themselves contribute to the formation of this cavity. The nasal bones are two minute tubercles implanted on the frontal bone above the narrow aperture. The malar is in the shape of a style, suspended by cartilages beneath the orbit; and the latter cavity is completed behind by a process of the frontal, which joins the zygomatic of the temporal bone, and below which the orbitar and temporal *fossæ* communicate.

Orbits.

The direction of the orbits, the shape of their base or facial border, and their relation to the temporal *fossa*, are important circumstances in the animal face and cranium. In the *simiæ* the angle of the orbitar axes is rather smaller; and the shape of the margin, which is quadrilateral in the jocko, becomes oval in the ourang-outang and American monkeys. The angle of the axes enlarges in the other Mammalia; and the base or anterior margin becomes nearly circular in the ZOOPHAGA, RODENTIA, EDENTATA, and PACHYDERMATA; but the arch is incomplete behind. In the *Ruminants* and SOLIDIPEDA, however, in which it is also circular, the border is complete. In the CETACEA the orbitar vault is semicircular, their axes are rectilineal, and there is no floor.

In the human scull the junction of the malar bone with the frontal and sphenoid completes the orbit externally, and prevents it from communicating with the temporal *fossa*; and the same arrangement is observed in the *simiæ*. In the CARNIVORA, RODENTIA, EDENTATA, and PACHYDERMATA, however, in which the malar bone is united neither to the frontal nor the sphenoid, the orbit is not only incomplete on the external posterior border, but communicates freely with the temporal *fossa*. In the Ruminants is observed an arrangement intermediate between that of the QUADRUMANA and that of the CARNIVORA. The malar bone, united to the frontal, completes the orbitar ring; but as it is not united to the sphenoid, it allows the orbits and temporal *fossæ* to communicate. The orbit of the mole is so superficial, that it can scarcely be said to exist.

The lower jaw.

The lower jaw of the mammiferous quadruped differs from that of man chiefly by the following circumstances. The triangular flat surface which constitutes the chin, and which is most distinct in the Caucasan race, begins to become faint in the negro, and is altogether lost in the monkey tribe. In the ourang-outang, indeed, the animal character of the lower jaw appears distinct in the vertical convexity of the anterior arch of the jaw, and the retreating of its lower margin. In the lower QUADRUMANA the anterior maxillary arch is still more retreating, and the maxillary *rami* form a more acute and elongated angle. These animal characters are still more conspicuous in the CARNIVORA, most of the PACHYDERMATA, Ruminants, SOLIDUNGULA, and RODENTIA. The ascending *ramus* also becomes short in the PACHYDERMATA and several of the CETACEA, more so in the ZOOPHAGA, and is almost extinct in several of the RODENTIA, for instance the paca, beaver, and porcupine, and the armadillo, ant-eater, and duck-bill, among the EDENTATA. In the ZOOPHAGA, however, in which the prehensile and masticatory muscles are large and powerful, the *ramus* becomes broad, and its coronoid process is extensive. The angle which the *ramus* forms with the body of the jaw, and which is almost right in the adult human subject, becomes obtuse in the lower animals, nearly at the same rate at which the *ramus* disappears; and indeed the transition of the angle into a straight line implies the disappearance of the *ramus*. This, therefore, is the character in the EDENTATA and CETACEA, in which there is neither *ramus* nor coronoid process, after these parts have been seen for the last time in the amphibious MAMMALIA.

When the mammiferous cranium is considered generally, and the relative direction and proportion of the cranial and facial part of the head examined, we recognise more distinctly the characters by which the lower orders of that class are distinguished from man. This character consists in the position of the occipital bone and hole, the position and direction of the facial bones in relation to the frontal, the elongation of the former, and large size which they present in relation to the cranial.

In the human subject, it has been already observed, the position of the occipital bone is oblique and horizontal, and the plane of the occipital hole is horizontal, while its position is anterior. In most quadrupeds, while the bone assumes a vertical position, the hole becomes posterior, and its plane vertical or oblique, in proportion as the face is elongated. The plane of the occipital hole forms with that of the horizontal a considerable angle, which Daubenton undertook to determine, by drawing one line through the plane of the aperture, and another from its posterior margin through the lower edge of the orbit. (*Mém. de l'Acad. des Sciences de Paris*, 1764, p. 568.) In the horse this angle is about 90°, while in the ourang-outang it is only 37°, and in the *lemur* 47°. In other respects, however, it furnishes an imperfect result, since in most quadrupeds which differ very much it ranges between 80° and 90°.

Camperian line and angle.

The direction of the face in relation to that of the cranium, determined according to the method of Camper, furnishes more accurate results. While in the human subject it varies, according to the races, from 70° to 80°, in the ourang-outang it is only 65°; in the American and long-tailed monkeys about 60°; in the macaca and baboon about 45°; and, lastly, in the mandrillo, the most vicious and ferocious of the monkey tribe, only 30°. In some species in which the ear is elevated and the guttural *fossa* deep, for instance in the pongo and *alouate* or howler, the small size of this angle does not indicate proportional elongation of muzzle; and to rectify this inconvenience, it is requisite to draw the basilar line of the facial angle parallel to the base of the nostrils. With this modification, however, the Camperian line admits of correct application to the human race and QUADRUMANA only, in which the frontal sinuses are small and not prominent. In quadrupeds, for instance the carnivora, several of the ruminants, and in the elephant, the frontal sinuses are so large and prominent as to affect the results given by the facial angle very materially. In other orders, again, for instance the RODENTIA and the morse, the nose occupies so much space that the cranium is inclined backwards without its walls being free before; and it is impossible to know where the facial line passes. These, therefore, must be measured by the inner surface. Lastly,

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in the CETACEA the pyramidal elevation of the cranium above an elongated but flattened face renders the facial line much more vertical than it ought to be. The following measurements show the angle subtended by a line drawn parallel to the base of the nostrils, and another passing by the anterior margin of the *alveoli*, and touching the convexity of the cranium, whether the point of contact be concealed by the face or not.

European infant	90°	Mastiff, tangent within	31°
European adult	85	Hyena, without	40
European aged	75	Ditto, within	25
Negro adult	70	Leopard, within	28
Young ourang-outang	67	Hare, within	30
American monkey	65	Marmotte, within	25
Java monkey	57	Porcupine	23
Young mandrill	42	Pangolin	39
Coati	28	Babiroussa	29
Pole-cat	31	Ram	30
Pug-dog	35	Horse	23
Mastiff, tangent without	41	Dolphin	25

Method of Cuvier.

Aware of the imperfect results obtained in this method of measurement, Cuvier proposes to estimate the relative proportion of the cranial and facial part of the head, by comparing the respective areas exhibited by a longitudinal and vertical section of both. In this section the area of the cranium is to that of the face sometimes in a ratio of majority, sometimes of minority, occasionally of equality.

In the European the area of the cranial section is about four times that of the face, excluding that of the lower jaw. In the negro the cranial area remaining the same, that of the face augments about one fifth, whereas in the Calmuck it augments only one tenth. In the ourang-outang the proportion is still less. In the American ape the facial is almost half the cranial area. The ratio is that of equality in the mandrill and most of the CARNIVORA, except the varieties of short-muzzled dogs, as the pug, in which the facial is rather less than the cranial area. In the RODENTIA, PACHYDERMATA, Ruminants, and SOLIDUNGULA, the facial is larger than the cranial area. Among the RODENTIA, in the hare and marmot, it is a third larger; in the hedgehog double; in the Ruminants almost double; in the pig a little more than double; nearly triple in the hippopotamus; and almost four times in the horse. In the morse and elephant the face is rendered large by the height of the *alveoli;* and it may be regarded as augmenting the organs of the senses. The cranium of the CETACEA is very convex, and the face very flat, and the proportional area of the latter is thereby diminished. The facial area of the dolphin may be a third larger than the cranial.

The outline of the cranial section in the human subject is oval, that of the facial section forms a triangle, with the longest side contiguous to the cranium, and the smallest without, while the angle formed by the latter with the third side or palate is the facial. In the lower animals, this triangle, which may be named the *facial*, becomes so much elongated, that the cranial side, which is the longest in man, becomes the shortest of the three in the *cynocephalus* and mandrill, and continues so in the other quadrupeds.

The pelvis.

The basin (*pelvis*) of the MAMMALIA in general agrees with that of man in forming a part common to the trunk and the lower extremities. It differs, however, altogether in the direction which it takes, which is obliquely backwards, with its anterior opening or brim forwards and downwards, and in the bones being smaller and much narrower; both of which characters are connected with its not being used in the lower animals to oppose the gravitating weight of the abdominal and pelvic *viscera*. In the apes, most similar to man, the coxal bones are much elongated; and in the ZOOPHAGA, their superior or ilial part is not much broader than their pubal. In the Ruminants, the PACHYDERMATA, and SOLIDUNGULA, the ilial portions again become broad; and in the elephant and rhinoceros especially, this width, combined with the length of the ilio-pubal *rami* and the concave abdominal surface, concurs to give the *pelves* of these animals the prodigious capacity by which they are distinguished. The *pelvis* of the amphibious MAMMALIA differs from that of the ZOOPHAGA only in being narrow and elongated, and in the *pubis* being thrown behind. In the ant-eater, mole, and shrew, the pubal junction is open as in birds; and in the two latter *genera*, the bones are so narrow that the sexual and urinary organs are placed without its circumference. In the sloth *genera*, e. g. the *Ai* and *Unau*, the pelvis is wide, the cotyloid cavities turned upwards, and the ischial tuberosity is united with the sacrum, so as to convert the ischiatic notch into a hole. This sacro-ischial junction is also observed in others of the EDENTATA, as the ant-eater and armadillo, and in the *phascoloma* (*didelphis ursina*). The marsupial animals present two minute bones, one on each side, connected by movable articulation to the pubis, and which are employed to sustain the mammillary pouch (*marsupium*) or nipple-bag, in which the young are reared after exclusion from the *uterus*. These bones, which are distinguished by the name of marsupial (*ossa marsupialia*), are oblong and flattened. Lastly, in the CETACEA, in which the pelvic extremities are wanting (Plate XXXIV. fig. 2), the pelvis is also so far deficient, that instead of consisting of the sacrum and coxal bones, it is represented by a small bony appendage, suspended in the soft parts on each side of the anus, and which, meeting at angles on the mesial plane so as to form a bone like the letter V, are merely a rudiment of the ischial bones.

The shoulder of the MAMMALIA generally differs from that of man by the absence or the proportions of the collar-bone, and by the shape of the *scapula*.

The collar-bone.

The collar-bone exists in the QUADRUMANA nearly as in man; but it is wholly wanting in the three orders of UNGULATA—PACHYDERMATA, the Ruminants, and the SOLIDUNGULA—and in all the CETACEA. Between these extremes it is found in various forms in the intermediate orders of the UNGUICULATA. Among the ZOOPHAGA it exists in the CHIROPTERA, especially the bats proper, in which it is strong and large; the INSECTIVORA, as the hedgehog, shrew, and mole *genera;* and in the didelphis or opossum among the marsupial animals. In the others of this order, as the bear, raccoon, coati, weasel, otter, dog, cat, and seal, the collar-bone is represented by clavicular bones, suspended among the muscles, touching neither the sternum nor acromion; and in some species it is altogether wanting. The RODENTIA may be distinguished into two subdivisions, as they are provided with or void of collar-bones. The first comprehends the squirrel, beaver, and mouse, with the *helamys*, marmot, and aye-aye or cheiromys *genera*. The second consists of the porcupine, hare, and cavy *genera*, as the guinea-pig and paca, in which the collar-bone is rudimental only, suspended among the soft parts. It exists in most of the EDENTATA, as the sloth, armadillo, ant-eater, and the gigantic fossil animal named *megatherium;* but it is wanting in the pangolin, and was believed to be wanting in the *echidna* and duckbill till Cuvier demonstrated its existence. In the CETACEA there is no vestige of collar-bone.

From these facts it results that the clavicle exists in all animals, the fore legs of which are frequently or habitually protruded, either to seize, as apes and the RODENTIA; or to fly, as bats; or to dig and burrow, as the mole; or to rake the ground, as the hedgehog and ant-eater. In the mole particularly, the collar-bone, instead of being long, is

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a broad, thick, short, quadrangular bone; and while it is connected to the acromion by a ligament, it is articulated to the humerus by a large facette. The collar-bone of the *echidna* and *ornithorhyncus* is very singular. It consists of a broad central bone, surmounted by two transverse branches spreading out on each side, so as to give the whole bone some resemblance to the letter T, but situated so as to make the diverging branches like the Greek υ. In young animals this bone consists of three portions. The two diverging branches are genuine collar-bones, and may be regarded as a bifurcated bone; while the middle is supported on the sternum, and has articulated to each side a part of the *scapula*, corresponding to the coracoid process. The collar-bone, indeed, is a powerful buttress, which prevents the arm-bone from being thrust too much forward.

The shoulder-blade.

Of the shoulder-blade or *scapula*, which is present in all red-blooded animals with thoracic extremities, and hence in all the MAMMALIA, the principal point is to remark the varieties which its shape presents. Though in man, most of the QUADRUMANA, the CHIROPTERA, and the elephant, the vertebral margin or base of several authors on human anatomy is the longest, it becomes the shortest in most quadrupeds, especially those which, like the Ruminants and the SOLIDUNGULA, have long legs and narrow chest. In most of them, also, this margin, instead of being straight, is rounded, as in the CARNIVORA and RODENTIA. In the CARNIVORA without collar-bone, the hedgehog and *didelphis*, the acromion is less prominent; there is another eminence directed backwards, almost perpendicular to the spine. The coracoid process, also, which is present in the CHIROPTERA, the hedgehog, and *didelphis genus*, is wanting in most of the zoophagous tribe. In the hare the acromion terminates in a long slender process, rising at right angles and bending backwards, which may be named the *recurrent*. In the Ruminants and SOLIDUNGULA, not only are this and the acromion, but even the coracoid, wanting. The *scapula*, again, of the hog and rhinoceros is remarkable for the disappearance of the spine at the glenoid angle; while from its middle proceeds a prominent process towards the costal or inferior margin. In the mole the scapula is long and narrow, like a cylindrical bone, placed parallel to the spine,—an arrangement which, together with the shortness and thickness of the clavicle, already mentioned, is evidently connected with the burrowing habits of this animal. Lastly, in the *echidna* and *ornithorhyncus*, which in so many characters of organization approach the AMPHIBIA on the one side, and the BIRDS on the other, the scapula is a single sinuous bone, attached by one extremity to the sternum and middle part of the clavicular bone, with the other loose; and in the middle an articular cavity, in which the head of the humerus is placed, and which evidently corresponds to the glenoid. In this instance, therefore, the clavicle and *scapula* may be regarded as united into a single bone.

The humerus.

The *humerus*, which exists in all the animals with thoracic extremities, undergoes considerable variations. In the lower animals generally it is much shorter than in man; and it is invariably shorter in proportion as the *metacarpus* is elongated. Thus, in animals with what is named a *cannon* bone, that is, one metacarpal, as in the horse and the ruminants, the *humerus* is so short that it is concealed in the soft parts as far as the cubit. In the CETACEA it may be said to attain its maximum of brevity. In the bat and sloth it is long in proportion to the rest of the body.

The *humerus* of the mole is perhaps the most extraordinary of all those of the mammiferous animals. Not only is it articulated with the *scapula* by a small head, but it is connected with a facette of the clavicle by another belonging to the great tuberosity, and between which and the head is a deep pit. The crest of the small tuberosity is so large, that it represents a square placed vertically, so that the *linea aspera* is above. The rest of the body of the bone, which is very short, is arched above, so that the cubital extremity is directed upwards. From this arrangement it results that the cubit is elevated above the shoulder while the palm is turned downwards,—a disposition necessary for the burrowing habits of the animal.

Radius and ulna.

In the *simiæ* the *radius* and *ulna* are arranged as in man, except that in the *cynocephalus*, mandrill, magot, and guenon, the coronoid process of the *ulna* is narrower, and the radial facette deeper. In the other MAMMALIA the *ulna* very generally disappears or becomes rudimentary only. In the bat family and the colugo (*galeopithecus*) the *ulna* is wanting or is represented by a slender style placed below the radius. These animals are therefore destitute of the power of pronation and supination. In the ZOOPHAGA, the *radius* and *ulna*, though separate, are void of rotatory motion; and the *olecranon* is compressed, and continued farther back than in man. In the PACHYDERMATA the *radius* is before and the *ulna* behind, and, though distinct, there is no rotation. In several of the RODENTIA, for instance the marmot, porcupine, &c. the coronoid process is small, and in others, *e. g.* the cavy, hare, and mouse family, it is altogether effaced. In the Ruminants the *ulna* is united immovably to the radius; and in the SOLIDUNGULA it is represented by an *olecranon* adhering to the posterior surface of that bone. In the CETACEA, though both bones are present, they are much flattened.

Carpus.

The *carpus* of the ape *genus* contains one bone more than that of man, situate between the pyramidal and large bone, and which seems to result from the trapezium being divided into two parts. Conversely, in the ZOOPHAGA, but especially in the dog, cat, hedgehog, shrew, bear, and seal, the scaphoid and semilunar are united into one large bone. Those which have a vestige of thumb, as the hyena and glutton, have the trapezium very small. The mole has not only 9 carpal bones, as the ape, but a large sickle-shaped bone, which is attached to the radial margin of the fore paw, and which gives it the shape proper to the habits of the animal. The toes are further very short. Of the RODENTIA, the hare resembles the ape; but in the beaver, marmot, squirrel, and cat, the scaphoid and semilunar make one bone; while in the porcupine the supernumerary bone is between the pisiform and metacarpal of the fifth toe. In the two-toed ant-eater there are only 6 carpal bones, 4 in the first row and two in the second; in the three-toed sloth there are only 5, 3 in the first row and 2 in the second; the pangolin has 7; the cachecame 8 and a rudimental small toe; the elephant 8, 7 wedge-shaped and one elongated, corresponding to the pisiform; and the other PACHYDERMATA 8. In the rhinoceros, which has only 3 toes, the trapezium only is wanting; but there is a supernumerary bone on the margin of the scaphoid, and on that of the unciform, as in the porcupine. The first range consists, in the Ruminants and SOLIDUNGULA, of 4 bones; in the former, excepting the camel, the second consists of 2, and the latter of 3. Those of the CETACEA, which are much flattened, are 3 in the first row and 2 in the second.

Metacarpus.

The MAMMALIA generally have as many metacarpal bones as toes, that is, never fewer than 3 or more than 5, with the exception of the Ruminants, in which these bones are in early life consolidated into one named the *cannon* bone. In animals which walk on the tips of the toes, or which use them as organs of prehension, the metacarpal bones are lengthened to nearly double; and hence in all these animals the *metacarpus* is erroneously named the fore leg, and therefore it has been imagined, that in several

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of our domestic animals the different parts of the lower extremity are articulated in opposite directions to those of man. Thus the fore leg of the horse, deer, sheep, and dog are in truth the *metacarpus* of these animals; and what is vulgarly named the fore knee or *cannon* bone of the horse, is actually the *carpus* or wrist-joint. It is therefore convex on the dorsal, and concave and inflected on the palmar aspect, exactly as the *carpus* of the human subject.

In the three-toed sloth, the three bones of which the metacarpus consists are mutually consolidated at the base and with the rudiment of a fourth toe. In the CETACEA, the metacarpal bones, which are much flattened, are also mutually united.

Fore toes.

In the MAMMALIA generally, if we include imperfect or rudimental phalanges concealed in the skin, there are never fewer than 3, nor more than 5. The Unguiculated animals generally have 5, perfect and imperfect. The character of the perfect fore toe or finger is to consist of 3 rows or phalanges, excepting the first of the radial side, which has only 2. In the QUADRUMANA this is separate, and opposable to the other toes, constituting a thumb, and giving this tribe of animals a prehensible organ entitled to the epithet of hand. It is, however, shorter and less perfect in other respects than the genuine thumb of the human hand. In the *coaïta* (*simia paniscus*) it is converted into a rudimental bone, concealed under the skin.

In the ZOOPHAGA, which have no power of grasping minute objects, the thumb or first toe is parallel to the others, and, though equal in length to these in the ursine family, it is shorter in the *mustela*, *viverra*, canine and feline *genera*. In the latter, which have the power of erecting the claws, to prevent them from being blunted in walking, the shape of the middle and unguinal phalanx is remarkable. The former is triangular prismatic, with two lateral and a plantar or palmar inferior surface. The third or unguinal phalanx is shaped like a hook, consisting of two parts. One, directed forwards, sharp and pointed, receives the nail or claw, in a long groove like a sheath. The second part of the hook, which is behind, rises vertically from the lower part by which it is articulated, and is produced into two processes, to which are attached the erecting muscles of the claw, which are flexors of the phalanx.

Among the RODENTIA there is a perfect but short thumb in the hare, beaver, and jerbois; a two-phalanx but concealed one in the squirrel, mouse, and rat family, porcupine, paca, agouti; and a one-phalanx concealed one in the cavy, guinea-pig, marmot, &c. In the EDENTATA the number of fore toes varies much; in the *Tamanoir*, and *Tamandua* or four-toed ant-eater, the thumb-toe is obliterated; in the *Ai* or three-toed sloth, both that and the fifth toe are obliterated; and in the two-toed ant-eater, and *Unau* or two-toed sloth, these, with the second toe also, are obliterated.

The elephant has 5 perfect toes, all concealed under the thick, callous hide of the foot. In hoofed animals with 4 toes, for instance the hog, tapir, and hippopotamus, the thumb-toe is in the shape of a small rudimental bone.

In the Ruminants the single metacarpal bone (Cheselden's figure of the Deer, Plate I.) is articulated with two digital phalanges, which constitute one of the distinguishing characters of this order—the cloven foot. In some genera, at the root of these two perfect toes are two small bones, often covered with horn, which represent two other toes. The last or unguinal phalanx is always trilateral in shape. In the horse and the SOLIDUNGULA generally, the two lateral toes are represented only by two bony styles, named the splint bones, situate on the two sides of the metacarpal or *cannon* bone. The three phalanges of the single toe which constitutes the foot are distinguished as the *pastern bone*, which is the first phalanx; the *coronet*, which is the middle or second; and the *coffin* bone, which is the third or unguinal phalanx, which has the shape of the hoof, rounded before, convex above, and flat below. To the back of the pastern joint are connected two sesamoid bones; and to the coffin bone is attached another, named the shuttle bone. In the CETACEA, all the phalanges, which are flattened, and often cartilaginous, are united in the fin or paddle.

The fore cannon bone.

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Thigh-bone.

The thigh-bone, which is single in all the classes, follows the type of that of the human frame in general figure and parts. In the MAMMALIA it is, however, proportionally shorter, and its length diminishes as that of the *metatarsus* augments. In the Ruminants and SOLIDUNGULA, for instance, it is so short that it is concealed by muscles against the belly; and hence it is too often overlooked and confounded with the leg. In other respects the general characters are, that it is not arched; that, excepting in the bear and some of the *simia* genus, *e. g.* the ourang-outang, it is shorter than the leg-bones; that its neck is very short, and more perpendicular to the *axis* of the *diaphysis* than in man; and that the great trochanter is raised above the head, which is directed inwards. In the *simiæ* it is quite cylindrical, and void of *linea aspera*. In the tapir the middle part is found flattened; and at the external margin there is a prominent crest, terminating in an unciform process. In the rhinoceros the great trochanter and the unciform process are so elongated as to unite almost, and form a hole between them and the *diaphysis*. The unciform process is observed also in the horse, beaver, and armadillo. The thigh-bone of the seal is so short, that the half of its length consists of the two articular extremities.

Leg-bones.

Though the leg-bones of the MAMMALIA bear a general similitude to those of man, the *tibia* alone is constant; and the *fibula*, after becoming unusually slender, and changing its position from the outside to the posterior part of the tibia, is converted into a mere appendage, and at length disappears entirely. Thus, though it is distinct, and occupies its usual position in the *simiæ*, in the CHIROPTERA it is extremely slender; and since the *femora* are directed backward, the *fibulæ* are turned towards each other. In several of the EDENTATA, for instance the phatagin, armadillo, and sloth, it is large, curved, and remote from the *tibia*. In the dog family and the RODENTIA it is altogether behind the *tibia*. In the mole and murine *genus* it is consolidated to the lower third of the *tibia*, leaving an empty trilateral space above. In the rhinoceros, elephant, and hog, the *fibula* is flattened and united to the whole length of the *tibia*. In the ruminants it is represented by a small bony appendage, placed on the outer margin of the *astragalus*, below the *tibia*, and forming the external or fibular ankle. Lastly, in the horse and SOLIDUNGULA, the *fibula* is reduced to a styloid rudimental process, which is firmly consolidated in the adult animal to the upper part of the *tibia*.

Between the *tarsus* of man and that of the other MAMMALIA the following are the principal differences.

The tarsus.

In the *simiæ* the fibular facette of the *astragalus* is nearly vertical, and the tibial is very oblique; and the *calcaneum* wants the tuberosity, except in the pongo. In the ordinary bat family the calcaneum is elongated into a styloid process, concealed in the substance of the membranous ubiform expansions; but in the roussette (*pteropus*) the tuberosity projects beneath the foot.

In the RODENTIA the calcaneum is produced considerably backwards, while the scaphoid, which consists of two parts, forms a tubercle on the sole. Among the EDENTATA the three-toed sloth is peculiar in having a tarsus,

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consisting of four bones only, the *astragalus*, *calcaneum*, and two cuneiform bones, the first of which is articulated not only with the *tibia*, *fibula*, and *calcaneum*, but with the large cuneiform bone, without any intermediate scaphoid bone. Its connection with the *tibia* is by means of a convex articular surface, which rolls on the external part of the tarsal end of the *tibia*. From this mode of articulation it results that the foot of the sloth admits neither of being elevated nor depressed, but simply of performing lateral motions of adduction and abduction, to which it owes the power of clasping the trunks of trees and climbing, but which renders progression difficult and laborious.

The hog has a scaphoid with three ordinary cuneiform bones, and a rudimental great-toe bone beneath the first. In the tapir and rhinoceros there are only two cuneiform bones. All the animals already enumerated have the same number of metatarsal bones as of toes.

In the Ruminants the cuboid and scaphoid bones are united, unless in the camel, in which they are distinct. At the outer margin of the pulley of the astragalus is a bone which represents the lower head of the *fibula*, and which is farther articulated to the upper surface of the os calcis. In this side also there are only two cuneiform bones, which are united in the giraffe. The two metatarsal bones are always united, as in the *metacarpus*, into one, which forms a posterior cannon bone. The SOLIDUNGULA resemble the camel in this, that the scaphoid is distinct from the cuboid bone, and that there are two cuneiform bones, while the peroneal rudiment and the corresponding articular surface of the calcaneum are wanting. The metacarpal are also consolidated into a single piece, named the hinder *cannon bone*, each side of which is provided with a minute bony style.

Third cannon bone.

Hind toes.

The toes of the QUADRUMANA and the MARSUPIALIA are longer than those of man; but the great toe is shorter than the others, and its metatarsal bone is susceptible of separation and opposition, as the thumb or thumb-toe of the hand. Hence Cuvier, in his first classification, distinguished the latter by the name of *Pedimana*. The *Aie-aie* among the RODENTIA appears to possess the same faculty. Among the ZOOPHAGA the great toe remains always conjoined with and parallel to the others; and in the canine and feline genera it is obliterated. Among the RODENTIA, that of the beaver is nearly equal to the other toes; those of the marmot, porcupine, and the murine genus, are shorter; in the paca it is almost obliterated; it is reduced to a single bone in the Cape gerboa; and the leporine genus have no trace of it. In the cavy, agouti, and guinea-pig, the great and small toes are each reduced to one bone. In the gerboa (*mus jaculus*) and alactaga (*mus sagitta*) the three middle metatarsal bones are united into a single one similar to the cannon bone of the Ruminants and SOLIDUNGULA; and while the two lateral toes are distinct, though short, in the former animal, they are obliterated altogether in the latter.

Among the EDENTATA, the ant-eater, *orycteropus*, pangolin, and armadillo, have five toes, of which the great is the shortest in all. In the sloth the great and small toe are reduced to one small bone. The other metatarsal bones are united at their base. The toes have only two phalanges, of which the unguinal are the largest.

In the subsequent families the metatarsal bones deserve particular attention. In the elephant and PACHYDERMATA, their tarsal extremity has a flat surface, and the phalangeal consists of a convex tubercle, which presents below a prominent line in the middle of the bone. In the SOLIDUNGULA this line is above and below both. In the Ruminants, in which the cannon bone consists of the two metatarsal bones, the line of union is represented by a deep line like the tract of a saw. The elephant has 5 perfect toes; the hog 4; the tapir and rhinoceros 3; the Ruminants have two perfect toes on one metatarsal bone, and two small ones attached behind its base. The SOLIDUNGULA have one perfect toe, and two imperfect, which are reduced to a single styloid bone. In these animals the body is supported in walking by the last or unguinal phalanx alone; and hence the term *foot* is not of the same import as in the human subject and animals similarly constructed. While indeed man supports his person in progression on the *os calcis* and the posterior or metatarsal phalanges, in the other mammiferous animals the former bone touches not the ground, but is always elevated above it a considerable height. All the zoophagous or unguiculated animals, excepting the plantigrade, support themselves chiefly on the unguinal and middle phalanges both of the fore and hind foot; and neither the posterior *phalanges* nor the *calcaneum* touch the ground, as is easily demonstrated on observing the gait of the hedgehog, dog, fox, cat, or similar individuals of the same family. The animals distinguished by the name of PLANTIGRADE are believed to support themselves on the entire foot. But though the foot is certainly spread on the ground more freely than in those already mentioned, by the bear, glutton, badger, and others, it appears that not the heel, but the *metatarsus*, is allowed to touch the ground in progression. In the Ruminants and SOLIDUNGULA, as already mentioned, the only part of the foot which is applied to the ground is the unguinal phalanx; and it is well known that the horse supports himself on the plantar surface of the coffin bone only.

Lastly, in the Amphibious Mammals, while the extreme brevity of the *humerus* and *femur* unfit them for progression on land without extreme awkwardness and difficulty, the expanded shape and oblique position of the metacarpal bones and phalanges, the length of the *tibia* and *fibula*, and the greater length of the first and last than the middle metatarsal phalanges, all concur to give these animals great facility in swimming. (Cuvier, *Ossemens Fossiles*, tome v. partie i. septieme partie.) In the CETACEA, again, while the total want of pelvic extremities renders motion on land quite impracticable, the fin-like disposition of the metacarpus and metacarpal phalanges, with the great strength of the lumbar, and the length of the coccygeal vertebræ, peculiarly qualify them for locomotion in the waters.

SECT. II.—OSTEOLOGY OF BIRDS.

Plate XXXIV. fig. 3.

The number of vertebræ of which the different regions of the spine consist, is not less variable in BIRDS than in the MAMMALIA. Some idea of these variations may be formed from the number exhibited in the following table by Cuvier.

Spine.

SPECIES.	Vertebræ of Neck.	Vertebræ of Back.	Sacral Vertebræ.	Coccygeal Vertebræ.
Vultur. Vulture	13	7	11	7
Falco fulvus. Eagle	13	8	17	8
—— *haliaëtus.* Bald buzzard	14	8	11	7
—— *buteo.* Buzzard	11	7	10	8
—— *nisus.* Sparrow hawk	11	8	11	8
—— *milvus.* Kite	12	8	11	8
Strix bubo. Eagle owl	13	7	12	8
Strix ulula. Brown owl	11	8	11	8
Muscicapa grisola. Fly-catcher	10	8	10	8
Turdus merula. Blackbird	11	8	10	7
Tanagra tatao. Tanagra	10	8	9	8
Corvus corone. Crow	13	8	13	7
—— *pica.* Magpie	13	8	13	8
—— *glandarius.* Jay	12	7	11	8
Sturnus vulgaris. Starling	10	8	10	9
Loxia coccothraustes. Grosbeak	10	7	12	7
—— *pyrrhula.* Bullfinch	10	6	11	6

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Species.	Vertebræ of Neck.	Vertebræ of Back.	Sacral Vertebræ.	Coccygeal Vertebræ.
Fringilla domestica. Sparrow...	9	9	10	0
——— *carduelis.* Goldfinch...	11	8	11	8
Parus major. Titmouse.....	11	8	11	7
Alauda arvensis. Lark.....	11	9	10	7
Motacilla rubecula. Red-breast	10	8	10	8
Hirundo urbica. Swallow.....	11	8	11	9
Caprimulgus Europæus. Goat-sucker.....	11	8	11	8
Trochilus pella. Colibri.....	12	9	9	8
Upupa epops. Hoopoe.....	12	7	10	7
Alcedo ispida. King's fisher...	12	7	8	7
Picus viridis. Woodpecker.....	12	8	10	9
Ramphastos. Toucan.....	12	8	12	7
Psittacus crithacus. Parrot.....	12	9	11	8+
Columba ænas. Stockdove.....	13	7	13	7
Pavo cristatus. Peacock.....	14	7	12	8
Phasianus colchicus. Pheasant	13	7	15	5
Meleagris gallopavo. Turkey...	15	7	10	5
Crax nigra. Curassow bird. Hocco.....	15	8	10	7
Struthio Camelus. Ostrich.....	18	8	20	9
——— *Casuarius.* Cassowary...	15	11	19	7
Phœnicopterus. Flamingo.....	18	7	12	7
Ardea cinerea. Heron.....	18	7	10	7
——— *alba.* Stork.....	19	7	11	8
——— *grus.* Crane.....	19	9	12	7
Platalea Aïaïa. Spoonbill.....	17	7	14	8
Recurvirostra. Avoset.....	14	9	10	8
Charadrius pluvialis. Plover...	15	8	10	7
Tringa vanellus. Lapwing.....	14	8	10	7
Scolopax rusticola. Woodcock...	18	7	13	8
——— *arquata.* Curlew.....	13	8	10	8
Hæmatopus. Oyster-catcher...	12	9	15	0
Rallus crex. Rail.....	13	8	13	8
Fulica atra. Coot.....	15	9	7	8
Parra. Jacana.....	14	8	12	7
Pelicanus onocrotalus. Pelican...	16	7	14	7
——— *carbo.* Cormorant...	16	9	14	8
Sterna hirundo. Sea swallow...	14	8	10	8
Larus. Gull.....	12	8	11	8
Procellaria. Petrel.....	14	8		8
Anas cygnus. Swan.....	23	11	14	8
——— *anser.* Goose.....	15	10	14	7
——— *bernicla.* Bernacle.....	18	10	14	9
——— *boschas.* Duck.....	14	8	15	8
——— *tadorna.* Sheldrake.....	16	11	11	9
——— *nigra.* Black diver.....	15	9	14	7
Mergus merganser. Merganser	15	8	13	7
Colymbus cristatus. Grebe.....	14	10	13	7

Cervical vertebræ.

In this table the most remarkable circumstance is the great number of cervical vertebræ, which are much more numerous than in the Mammalia. They vary from 9, the number in the sparrow, to 23, which is that of the cervical vertebræ of the swan. The most common number is 11, which is that of 10 *genera*. The next most frequent is 12, 13, and 14, which are equally the numbers of 9 *genera*. The next is 15, which is that of 8; 10 occurs in 6, 18 in 4, and 16 in 3. In the stork and crane they are 19.

Dorsal vertebræ.

The next remarkable circumstance is, that the dorsal or costal vertebræ are greatly fewer than in the Mammalia, never exceeding the number of 11, and being more frequently about 7 or 8. Thus, while they are 11 in the cassowary, swan, and sheldrake, 10 in the goose, bernacle, and grebe, and 9 in the sparrow, lark, humming-bird, parrot, crane, avoset, oyster-catcher, cormorant, and black-diver, they are 7 or 8 in all the other *genera*, and only 6 in the bullfinch.

There are no lumbar vertebræ strictly so named, for those which extend from the chest to the tail are consolidated into one piece with the iliac bones. The tail, which is short, consists of from 7 to 9 vertebræ.

Neck.

The part most variable in proportional length is the neck. It is so much longer as the feet are elevated, except in some of the swimmers, in which it is greatly longer, because they require to seek their food below the surface of the waters on which they float.

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The bodies of the cervical vertebræ are articulated not by plane facettes, which would admit obscure motion only, but by portions of cylinders, which allow extensive motion. The 3d, 4th, or 5th superior vertebræ allow of anterior inflection only, and the others of posterior inflection. This gives the necks of birds an alternate serpentine inflection; and it is by rendering the two arches, of which this curvature consists, straight or convex, that the animal elongates or shortens his neck. The articular processes of the superior vertebræ are directed upwards and downwards; those of the lower are turned anteriorly and posteriorly.

Instead of transverse processes, the cervical vertebræ of birds are provided with a tubercle above, and the anterior extremity of which terminates in a narrow style, descending parallel to the body of the vertebra.

Only the most superior and inferior vertebræ have distinct spinous processes, and these have anterior as well as posterior ones. The middle ones have before two crests, which form a half-canal, and behind a tubercle, often bifid, or, when they are elongated, two rough lines. The atlas, which is articulated with the occipital bone by a single facette, has the shape of a minute ring.

Back.

As the neck of birds is movable, the back is fixed. The spinous processes of these vertebræ are in mutual contact, and they are connected by strong ligaments. Most of these processes are generally consolidated into a single continuous crest, extending along the whole back. The extremities of the transverse processes terminate in two *apices*, one directed forwards, the other backwards; and occasionally they are consolidated into a continuous mass like the spinous. That this arrangement is requisite for the trunk to remain fixed during the violent motions which take place in flying, is rendered probable by the fact, that in birds which do not fly, as the ostrich and cassowary, the spinal column retains its mobility.

The last dorsal vertebræ are often placed on the crest of the iliac bones, and they are then united, as the lumbar, on the large piece of the iliac bones, from which it results that the number of vertebræ can often be estimated in no other mode than by that of the holes of the nerves which issue from the chord.

Caudal vertebræ.

The caudal vertebræ are most numerous in the species which move the tail with most energy; for instance, the magpie and swallow. They have spinous processes below as well as above, and very long transverse processes. The last of all, to which the pinions are attached, is longest, and has the shape of a ploughshare or a compressed quoit. In the cassowary, which has no visible tail, the last bone is conical; in the peacock, on the contrary it has the shape of an oval plate, situate horizontally.

Cranium.

It was early observed by the original zoologist and traveller Pierre Belon, that the *crania* of birds were void of sutures; and that in a few only were these lines of distinction into separate bones recognised. The explanation of this peculiarity is found in the history of the ossification of the head in young birds, which shows that the cranium consists at that period of separate bones, corresponding in number and situation to those of quadrupeds. Thus, there are two frontal bones, which are continued forwards to form the vault of the orbits; two small parietal bones behind the frontal; a temporal bone on each side of the scull; a sphenoid united to the occipital, even in subjects in which the other sutures are distinct; or a spheno-occipital bone, which is early united with the temporal.

These sutures, however, are distinctly seen only in

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young birds and those recently hatched; for the bones are very early united, and in the adult bird the cranial sutures are invariably obliterated. Thus, in the domestic fowl and turkey the scull is one piece; and the only trace of suture that remains is a linear depression in the middle of the frontal bone, indicating the original formation in two halves. In the recently hatched bird, also, the sphenoid is separated from the occipital bone by a transverse suture, extending from the one ear to the other. The occipital bone is at the same time a ring, consisting of four parts; a superior, two lateral, and an inferior which is small. The sphenoid, which forms the greater part of the base of the cranium, is nearly trilateral, with a small anterior process, to which the palatine arches are articulated. It has no pterygoid processes, and does not touch the posterior aperture of the nostrils. The temporal bone, though void of zygomatic process, has a pointed style, which contributes to form the posterior margin of the orbit. The frontal bone, after covering part of the cranium, is continued forwards in a broad, thin plate, which forms the vault of the orbits, while these cavities are separated by a thin vertical bony plate which descends at right angles from the frontal bone, and is connected behind with the sphenoid. The long eminences observed on the heads of the cassowary, curlew, pintado, and some species of hocco, are produced from this supra-orbital part of the frontal bone; and their interior, which consists of loose *diploe*, communicates with that of the same bone.

Facial bones.

The face in birds is rarely so firmly consolidated as the cranium. It is composed of two lacrymal bones, forming the anterior margins of the orbits, and united on the mesial plane; two nasal bones anterior to the lacrymal; two bones corresponding to the superior maxillary, and forming the external lateral parts of the upper half of the bill; two inter-maxillary bones; two anterior palate bones, corresponding to those of the MAMMALIA; two posterior palate bones corresponding to the pterygoid processes of the sphenoid; and the lower jaw a paraboloid bone, consisting of two *rami* united before, where they are covered by the horn of the lower half of the bill. Besides these, there is in the whole class an irregular-shaped bone, common to the cranium and lower jaw, and connecting these two together. This bone, which has been rather improperly named the square, quadrangular, or quadrilateral bone (*os quadratum*), consists of a body with curvilinear hollow margins, terminating in two elevated and rather pointed processes, one of which is connected with the cavity named *tympanum*, while the other, projecting into the orbit, affords attachment to several muscles. The anomalous character of this bone has perplexed several of the most distinguished zootomists; and while Geoffroy gives it the name of *os Tympano-styloideum*, Spix considers it analogous to the annular process of the temporal bone, which in the human fœtus is separate; and Carus regards it as representing the *incus*, to which it bears a remote resemblance in shape and in one of its connections.

The quadrilateral bone.

Maxillary bones.

Both *maxillæ* are void of teeth; but the hard, horny matter of the bill covering the margins and extremities of each jaw, and constituting the mandibles (*mandibula*), is manifestly constructed to perform for BIRDS what teeth do for the MAMMALIA. But the most remarkable peculiarity of the, facial bones of this class is, that the upper jaw admits of more or less motion. In the majority of instances this is effected by the jaw being united to the cranium by means of thin, flexible, elastic, bony plates; but in the parrot family the upper jaw is entirely distinct, and is connected by a proper articulation.

The base of the palatine surface of the upper jaw is divided into 4 branches, which diverge backwards. The two external ones, which correspond to the zygomatic arches of the MAMMALIA, and which are very slender, are articulated to the quadrangular bone which moves on the temporal before the ear. The two intermediate ones, which have been already stated to correspond to the pterygoid processes, and which are parallel, are placed beneath the septum of the orbits, and are articulated by their posterior extremities with a small bone, variable in shape, but named *omoid* by Herissant, which is also articulated with the quadrilateral. From this arrangement results a singular species of broken lever, not dissimilar to the parallel joint of the piston and lever of the steam-engine, and the effect of which is, that whenever the lower jaw is depressed by its proper muscles, it necessarily causes the quadrilateral bone to perform a slight rotatory motion, in consequence of which, by means of the omoid bone, the upper jaw is at the same time elevated on the elastic plates; and as soon as the lower jaw is raised, the elasticity of these plates forces down the superior one.

The upper jaw is immovable in a few instances only, and of these the *calao* or rhinoceros bird is one.

Sternum or breast-bone.

The breast bone (*sternum*) is a trilateral, boat-shaped bone, concave internally, convex with a middle longitudinal crest externally, with the base of the triangle above, and the apex, which is also incurvated backwards, below. The middle longitudinal crest, which is occasionally named the keel (*carina*), is shaped something like a spherical triangle, with the broadest side above, the base before, and the apex behind; and its prominence forms large spaces on each side for the attachment of the pectoral and other muscles used in flight. In the male wild swan (*anas cygnus*), in some species of curlew, in the crane, and in the guinea-fowl, this crest forms a cavity for the reception of the windpipe. In the ostrich and cassowary, which do not fly, the sternum is void of crest, and is merely arched strongly.

The ribs.

The ribs, which rarely exceed 10 pairs, may be distinguished into sterno-vertebral and vertebral. Though the latter are generally before, they are sometimes also behind. The vertebral end terminates in two diverging processes, one of which is articulated with the vertebral body, the other with the transverse process. The sternal extremity consists of a bony process, which performs the part of the sterno-costal cartilages of the MAMMALIA by uniting the rib to the sternum. The ribs of birds, however, are further distinguished by presenting near their middle a flat long process, projecting from the rib backwards at an acute angle, and resting on the rib immediately below, so that each rib is supported not only on the vertebræ and sternum, or the vertebræ alone, but on the next rib below. These processes are obliterated in the lower ribs.

Basin or pelvis.

The coxal bones constitute one piece with the sacrum and lumbar vertebræ. The ischial portion is united with the sacrum, and the ischiatic notch is converted into a hole. The part which corresponds to the *os pubis* of the MAMMALIA is not consolidated before so as to form a symphysis, but proceeding directly backwards, terminates in a styloid process, variable in length and slenderness. The only exception to this mode of structure occurs in the ostrich, in which the pubal bones are united below. The infra-pubal or oval hole is present in the whole class notwithstanding. It is worthy of remark, however, that in young birds this and the ischial aperture are still notches, in consequence of the deficient ossification of the parts.

The direction of the *pelvis* in birds is nearly that of the spine, that is, obliquely backwards, and deviating but little from the horizontal line.

Collar-bone.

The wings or thoracic extremities are connected to the trunk by three bones, the collar-bone or clavicle, the *scapula*, and the bifurcated bone. The collar-bones, which

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are straight, strong, and cylindrical, are articulated by a large head with the anterior and lateral part of the sternum, in which its motion is rather limited. It forms before and laterally two short processes, one anterior-inferior and internal, articulated with the bifurcated bone; the other posterior-superior and external, uniting with the scapula, and forming a cavity, in which the head of the *humerus* is lodged.

Shoulder-blade.

The *scapula* is a long bone, flattened, but narrow, and slightly incurvated, with the convex side turned towards the spine, to which it is nearly parallel in position. The head or anterior extremity is thick and extensive, oblique from before backwards, and is articulated behind with the clavicle, before with the *humerus*. The free extremity is thin, flattened, and sharp. The whole bone is not dissimilar in shape to a scimitar.

Bifurcated bone, or *Furcula*.

Besides these, which Birds possess in common with the Mammalia, we find an azygous bone, situate on the mesial plane, denominated in ordinary language the *Merry thought*, and, from its shape, the fork-like or bifurcated bone. It consists of two long, rounded, converging branches, united at an acute angle, and forming a broad process, flat in the vertical direction, and by which it is articulated to the anterior extremity of the crest or carinated part of the breast-bone. To the posterior or free extremities of the divergent branches are articulated the humeral ends of the collar-bones, which are thus enabled to sustain the violent motions of the humerus during flight. The branches of the bifurcated bone are separate in the ostrich, and each is united with the clavicle and *scapula* of the same side, so that the three bones form only one, much flattened, and with a hole towards the sternal extremity. In the cassowary the bifurcated bone is reduced to a mere rudimental process at the inner margin of the head of the clavicle. From these facts it results, that the bifurcated bone is particularly useful in the energetic and continued efforts of the wings in flight, and not only serves to keep the clavicles apart, but, by lengthening the distance between the collar-bones and sternum, enables the animal to use a longer lever. It is freest, strongest, and most elastic in the birds which fly best. In birds which do not fly, and which use the wings merely to sustain the equilibrium, as the ostrich and cassowary, it is reduced to almost nothing, or it is in such a rudimental and imperfect form, that it cannot keep the collar-bones apart.

Thoracic extremities.

The bones of the thoracic extremities, or those of the wings, correspond in general to those of the Mammalia. They consist of a single cylindrical humerus, articulated with the *scapula* and collar-bone above, two bones of the fore wing corresponding to the *ulna* and *radius*, two bones of the *carpus*, two of the *metacarpus*, consolidated by their extremities, one styloid bone as a thumb, a long finger consisting of two *phalanges*, and a short one consisting of one. The thumb supports the bastard pinions, the large finger and *metacarpus* the primaries, while the small one, which is covered by the skin, is destitute. In several of the web-footed divers, for instance the duck and penguin (*alca impennis* and *spheniscus*), these bones are flattened like thin plates.

Pelvic extremities.

In the pelvic extremities the thigh-bone is provided with one trochanter only, is shorter than that of the leg, and is almost invariably straight; and is arched only in the cormorant, duck, and dobchick. In the ostrich its diameter is about four times that of the *humerus*. The *tibia* differs from that of the Mammalia chiefly at its lower extremity. While the *fibula* adheres to it like a slender appendage as far as the middle, the tarsal extremity terminates in two trochlear condyles, with an intermediate pulley-like groove. The *tarsus* and *metatarsus* are represented by a single bone of considerable length, and the head or tibial end of which consists of a middle prominence and two lateral depressions, and which, therefore, moves in cardinal opposition, but does not admit of extension beyond the straight line. Though variable in proportion to the length in different orders, this bone is very long in the order Grallæ (Grallatores). It terminates below in 3 pulley-shaped processes, to which are attached the bones of the 3 anterior toes, with an internal margin for that of the great toe. In the ostrich there are 2 processes only, corresponding to the two toes. In the penguin tribe, however, the *tarsus* and *metatarsus* consist of 3 bones, separate from each other in the middle, but united at the tibial and digital extremities. To the tarso-metatarsal bone of the cock, and others of the Gallinaceous tribe, is attached the spur, a conical pointed excrescence of hard horny matter.

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SECT. III.—OSTEOLOGY OF THE REPTILES.

The number of vertebræ, and all the other attributes of the spinal column, vary more in this class than in all the others.

Vertebræ.

In the Cheloniad or Tortoise family there are 7 cervical, 8 dorsal, connected with the shell in an immovable piece, so as to have neither processes nor articular facettes; from 3 to 5 lumbar and sacral, consolidated in like manner; and about 20 caudal or coccygeal. (Plate XXXIV. fig. 5.)

In the Saurial or Lizard tribe, the number 7 predominates in the cervical, being that of the crocodile and most lizards. In several, however, there are 8, as in two of the monitor genus, the American safeguard, the lizard of Fontainebleau, the dragon, the iguana, the anolis, and the gecko and scinc; and in a few, as the Nilotic monitor, and an undetermined species of monitor, they amount to 9. In the chameleon there are only 5 cervical vertebræ. Here, however, a singular peculiarity is observed. Instead of the cervical vertebræ being, as in the Mammalia, distinguished by being unconnected with ribs, to those, from the third to the seventh inclusive, short ribs, unconnected with the sternum, are attached. The *atlas* and *axis*, therefore, alone are proper *cervical* vertebræ; but the general analogy is observed in the cervical ribs being exceedingly short and almost rudimental. The dorsal vary from 11, which is that of the crocodile and iguana, to 29 and 30, which are the numbers in the New Holland scinc and Nilotic monitor. In the American safeguard, *cordylus*, stellio, crested basilisk, dragon, guana, and great anolis, they are 16; in the chameleon, black safeguard, and ameiva, 17; in the tupinambis, spotted gecko, and golden scinc, 18; in the green lizard and spotted guana (*polychrus*) 19; in the Fontainebleau and gray lizard 20; 21 in the Levant scinc and undetermined monitor; and 22 in the Java and New Holland monitor.

The Batrachoid or Ranine reptiles are void of ribs, and it is impossible therefore to distinguish the first three orders of vertebræ from each other. In general, however, there are from the nape to the *pelvis* 8 vertebræ, all provided with long transverse processes, and which are longest in the last. The *sacrum* is represented by a long flattened but pointed bone, without *coccyx*. In the Surinam toad (*rana pipa*) the last vertebra is consolidated with this bone; and the transverse processes of the second and third vertebræ are so much larger than the others, that they resemble rudimental ribs. In the Salamander family there are from the head to the sacrum 14 vertebræ, all alike in shape except the first, which receives the occipital bone, and the last, which is articulated with the sacrum. These two are distinguished by wanting rudimental ribs, which are small elongated bones, movable, and articulated with the trans-

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verse processes, which are directed backwards. The articular processes are large and imbricated, the posterior resting on the anterior, so as to resist the motion of the spine backwards. The sacrum consists of one vertebra only, but the coecyx or tail is composed of 27.

In the SERPENTINE tribe the vertebræ may be said to attain the most extensive numerical developement. With the exception of the head and rudimental ribs, they constitute the whole skeleton. (Fig. 3.) From the head to the tail their shape is the same, and may be distinguished into body, articular and transverse spinous processes. In some species, for instance the *boa*, the spinous processes of the back are so much separated as to allow mutual motion to a considerable extent. In others, conversely, for instance the rattlesnake, these processes are so long and broad as to touch each other, while the oblique processes, which form their bases, are imbricated over each other. In consequence of this arrangement the motion of the spine is limited behind, but more extensive on the ventral surface. The vertebral bodies, which move easily on each other, are provided with a sharp spine directed towards the tail, which somewhat limits motion in this direction.

The first vertebra differs from those of the rest of the body in supporting short or rudimental ribs; there are therefore no cervical vertebræ and no proper neck in the serpent family. The caudal vertebræ are distinguished by not supporting ribs, and by their spines both dorsal and ventral being double, and forming two rows of tubercles. The articulation of the bodies of these vertebræ is peculiar. On the anterior part of the body is a round hemispherical tubercle, while the posterior presents a corresponding cavity, so that each vertebra forms a cup and ball joint with the following one.

The number of costal vertebræ varies from 32, which is that of the blind worm (*Anguis fragilis*), to 204 in the ringed snake (*Coluber natrix*), 244 in the snake, and 252 in the *Boa constrictor*, and which is perhaps the greatest known number. Of intermediate numbers, the *Amphisbæna* has 54, the viper (*Coluber berus*) has 139, the rattlesnake 175, and the cobra di capello 192. The caudal vertebræ vary in number from 7, which is that of the *Amphisbæna*, to 112, which is that of the *Coluber natrix*. Of intermediate numbers, the blind worm has 17, the rattlesnake 26, the boa 52, the viper 55, and the cobra 63; from which it appears that the number of the caudal is not in proportion to that of the costal vertebræ.

Cranium.

Of the heads of the CHELONIADS, the most remarkable characters are, that the facial line is horizontal, and quite continuous with the cranial line; that the orbits, though complete without, are continuous behind with the temporal fossæ; that the parietal and occipital bones are compressed laterally, while the latter terminates above in a sharp spine, projecting behind. The occipito-parietal and occipito-temporal sutures are distinct. The cranial cavity is small compared with the volume of the scull.

These characters are not less remarkable in the SAURIAL or LACERTINE Reptiles. The cranium of a crocodile measuring from 13 to 14 feet is scarcely capacious enough to admit the thumb; and Cuvier estimates the area of the cranial section, which is oblong, at about $\frac{1}{20}$ of that of the whole head. In these animals, indeed, the bones of the superior and inferior jaws are so much prolonged, and occupy so large a proportion of the head, that small space is left for the proper cranial cavity, which indeed is an immediate continuation of the vertebral. In these animals, also, the anatomist can trace, much more distinctly than in the more perfect, the resemblance between the cranial bones and the vertebral. In the CHELONIADS, and SAURIAL especially, the occipital bone is very distinctly a cephalic vertebra.

Still more manifest is this arrangement in the RANINE or BATRACHOID and SERPENTINE or OPHIDIAL Reptiles. In the former, as exemplified in the frog, the occipital bone, which forms the posterior cranial vertebra, consists of four pieces, and has two articular processes. The middle cranial vertebra is represented by the parietal bones above and the posterior part of the sphenoid below, while between it and the occipital or posterior is contained the temporal as the organ of hearing. The third or anterior cranial vertebra is represented by the anterior part of the sphenoid bone below and the two narrow frontal bones above. The face, which may be regarded as the organ of the senses, is elongated anterior to the head, somewhat after the manner of the CHELONIAD family; while an approximation to the BIRDS is indicated in the articulation of the lower jaw, which is connected to the head by the intervention of a quadrilateral bone.

In the Serpentine family, the cranium of which is very similar in other respects, the most remarkable deviation is in the want of ethmoid bone. The lower jaw is connected to the cranium by an intermediate bone, corresponding to the quadrilateral, but of an oblong shape, and something like a collar-bone.

Chest.

The chest of the REPTILE class varies much in the mode of formation. While true ribs are recognised in the SAURIAL family only, the BATRACHOID reptiles have a sternum without ribs, the SERPENTINE ribs without sternum, and the CHELONIAD ribs united into the dorsal shell, and a sternum expanded into the abdominal one.

Ribs.

In the SAURIAL family the ribs correspond in number to that of the costal vertebræ already mentioned, that is, 12 in the crocodile and iguana, two of which are not connected to the sternum, 17 in the chameleon, 18 in the tupinambis, and 27 in the monitor. The SAURIAL reptiles, however, are peculiar in having from 1 to 6 ribs attached to the cervical vertebræ, and the opposite ends of which are not connected to the *sternum*. These, which have been named cervical ribs, form a transition to the rudimental ribs of the SERPENTINE family, which are larger in the neck than elsewhere. The sternum of the crocodile consists of two parts,—an anterior or thoracic, which is osseous, supporting the two collar-bones,—and a posterior or abdominal, which is cartilaginous, and extends to the *pubis*, and furnishing to the abdominal parietes eight cylindrical cartilages. In the East India crocodile it appears that these lateral processes are converted into a single broad piece of cartilage on each side. (Fig. 4.)

Dorsal and sterno-abdominal shells of the Cheloniad.

The ribs of the CHELONIAD family are represented by the dorsal shell, which consists of eight broad incurvated plates, identified behind with the dorsal vertebræ, and terminating before in the margin of the shell, and which are doubtless genuine ribs. In the ordinary land-tortoise (*Testudo Græca*) these are seen in the shape of elevated bony ridges, proceeding from the head of each rib in a transverse concave bend to the margin of the dorsal shell. On each side of these ridges the bone is depressed, and is united at its lowest point by a genuine suture with the adjoining ones. These sutures, however, are not continuous with those of the sterno-abdominal shell, but meet it in the intermediate points. (Fig. 5.) The sterno-abdominal shell consists, in like manner, of several transverse pieces consolidated into one. The ordinary number is eight on each side of the mesial plane, and a ninth azygous, generally placed in the centre of the shell. In a specimen, however, of the tabular tortoise (*Testudo tabulata*), in our possession, the number of the sterno-abdominal pieces is 11, of which 8 are in pairs, united on the mesial line from before backwards, and 3 azygous at the posterior tip of the shell. In young animals it is easy to recognise the unions of these constituent bones, which consist of sutures ex-

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actly similar to those of the cranium in the MAMMALIA. So feeble is the union, that it often happens that the abdominal shell especially separates at the lines of junction, in the attempt to detach it from the dorsal.

The BATRACHOID REPTILES, though void of ribs, are provided with a *sternum*, which before is a cartilaginous process, terminating on a disc placed below the larynx, where it receives the collar-bones, and forms behind a broad plate placed below the abdomen, and giving attachment to the muscles. In the Salamander tribe, which are without *sternum*, the ribs consist of twelve pair of small rudimental processes, articulated with the vertebræ, but admitting of very limited motion.

Lastly, in the SERPENTINE family, though there is no sternum, the upper vertebræ are provided with costal processes, quite rudimental. The great number of these costal rudiments, amounting in the rattlesnake to 175, in the *cobra di capello* to 192, in the *coluber natrix* to 204, and in the *boa constrictor* to 252, and the freedom of their anterior extremities, enable the animals of this tribe, which are destitute of locomotive members, thoracic or abdominal, to employ the spinal column and the ribs as organs of progressive motion. On this point the reader will find some interesting observations by Sir Everard Home (*Phil. Trans.* 1812, p. 163). In the region of the neck, where the ribs acquire peculiar length, they are employed in erecting that region, and producing the expansive swelling peculiar to this tribe of animals. It is an important link in the same series of facts, that in the animal absurdly named the flying lizard (*draco volans*), the five posterior ribs are recurvated and elongated to form the bony skeleton of the membranous sails by which the animal supports itself in its desultory flight from tree to tree.

Thoracic extremities.

It is in the SAURIAL family that the locomotive extremities of Reptiles ought first to be studied. In these we find an elongated *scapula* without spine, and one short flat bone, constituting the clavicle, united to the sternum. In the iguana and chameleon this bone is broad and nearly quadrilateral, while in the tupinambis it is large and oval-shaped, with its greatest length from before backwards, and with two unossified points.

In the RANINE tribe, while the *scapula* consists of two articulated pieces, the upper towards the spine, each shoulder is provided with two collar-bones attached to the two extremities of the sternum, and the two anterior of which correspond to the bifurcated bone of birds. The *sternum*, collar-bone, and first part of the *scapula*, form one piece. In the salamander, in which the same consolidation is observed, the scapular portion is most distinct and directed to the spine, while of the clavicular portion the part connected to the sternum stretches below the chest, but, without uniting with that of the opposite side, the right glides over the left,—an arrangement which facilitates the dilatation of the chest during inspiration.

A nearer approach still to the bifureated bone than is seen in the RANINE may be recognised in the CHELONIAD family. In these animals three bones are united to form the humeral cavity. The first is a flat, trilateral bone, situate below the abdominal and thoracic *viscera*, close to the abdominal shell, and which, notwithstanding its situation, is evidently the *scapula*. The second is a bone about the same length, flat, and like the feather of an oar at one extremity, which is free, round in the middle, and flattened in the opposite direction at the other end, which is firmly united at a right angle to a long slender cylindrical bone. At the angle of union of these two bones is part of the glenoid cavity, which is complete in the small end of the scapula. The first of the two bones is the collar-bone proper; the second is the lateral branch of the bone, which forms the bifurcated, and which is occasionally united with its fellow. (Plate XXXIV. fig. 5.) The abdominal shell we have already stated to represent the sternum or breast-bone.

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The *humerus* in the SAURIAL and CHELONIAD family is arched and incurvated in a serpentine direction. It is articulated with a *radius* and *ulna*, which are succeeded by three rows of carpal bones, one row of four metacarpal bones and digital phalanges, varying in number in different *genera*. In the skeleton of a fossil animal belonging to the SAURIAL tribe, originally delineated by Collini, and afterwards by Cuvier, and named by him the *Pterodactyle* or Wingtoe (*Pterodactylus*, *OSSEMENS FOSSILES*, tome v.), the metacarpal bone and *phalanges* of the *index* are prolonged to about twenty times the ordinary length, for the purpose, apparently, of giving attachment to the membranous web by which the animal occasionally elevated itself into the atmosphere. This animal, which, like the dragon (*draco volans*) of modern times, must have combined the contradictory characters of a flying reptile, may be regarded as forming the link between the REPTILES and BIRDS, as the *Ichthyosaurus* does between REPTILES and FISHES.

Fossil skeleton of winged reptile.

Pelvis.

In the *pelvis* of the CHELONIAD family it is remarkable that the pubal and iliac bones appear to change places. Thus the *ilium* on each side is a narrow bone proceeding backwards to the sacral part of the spine, which is received between its posterior aperture; while the *pubis* appears in the shape of a broad, trilateral, flat bone, uniting before with its fellow on the mesial plane, behind with the *ilium*, and below with a flat, thin, quadrilateral bone, corresponding to the *ischium*, with which it forms the oval aperture. The inner of these three bones presents, as usual, the cotyloid cavity. It is further to be observed, that the two iliac bones, and consequently the whole *pelvis*, are movable on the vertebral column. (Plate XXXIV. fig. 5.)

Pelvic extremities.

In the SAURIAL Reptiles the pelvic bones are arranged and shaped nearly as in the CHELONIAD. In the RANINE the iliac bones are much elongated, and the pubal and ischial are consolidated into one piece, the symphysis of which forms a rounded crest.

The *femur* is short, thick, and incurvated sinuously, with the convexity before towards the tibial end, and the concavity towards the pelvic. Trochanters, though present in the CHELONIAD, are wanting in the SAURIAL and RANINE Reptiles. In the leg we find both *tibia* and *fibula* distinct, and of nearly equal size, in the CHELONIAD and SAURIAL family, but conjoined in the RANINE family. The *tarsus* consists of five bones, and sustains four or five metatarsal ones, on which are supported three rows of phalanges. The metatarsal bones, which vary in length, are longest in the crocodile and others of the LACERTINE tribe. In the RANINE, again, the *astragalus* and *calcaneum* are the bones of greatest proportional length.

The anatomical characters now enumerated are proper to the skeletons of Reptiles at present existing on the surface of the earth or in its waters; and in these we find a gradual transition from the SAURIAL and CHELONIAD, by means of the SERPENTINE, to the finny inhabitants of the ocean. Even the BATRACHOID Reptiles, in the early period of their existence while tadpoles, we shall have occasion to see, approach to the FISHES; and in one singular genus, if not two, the *Proteus anguinus* and *Siren Lacertina*, the characters of the Reptile are combined with those of the Fish, in having at once lungs or internal respiratory cells, and gills or external ciliated branchiæ. The transition thus indicated is still more strongly demonstrated in the osteological characters of two *Genera* of animals now extinct, so far as is yet known,—the *Ichthyosaurus* and the *Plesiosaurus*.

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Osteological peculiarities of the Ichthyosaurus

From the specimens of the *Ichthyosaurus* hitherto discovered, it appears that the number of vertebræ varies from 80 to 90 or more; in one entire specimen they amounted to 104 (Conybeare and De la Beche); that they are flattened, with the transverse diameter greater than the longitudinal, and the two articulating surfaces of the bodies calycoid or cup-shaped as in Fishes. Though the annular part is distinct from the body, it is united to its sides. The spinous processes, which are long and prominent, form a continuous ridge above the spine, and are connected to each other by a process from the front of the one spine, which is inserted into a pit in the back of the other. Instead of proper transverse process, a certain number of the vertebræ are provided with two tubercles on each side of the body, of which the superior, convex, is articulated to the tubercle of the rib, while the other, which is concave, receives the head. In the inferior part of the vertebral column, these two tubercles, after approximating, are eventually identified into one.

The ribs, which are numerous, and extend from the *occiput* to the *pelvis*, are slender and trilateral in shape, bifurcated above, and attached to the vertebræ by a head and tubercle. In the perfect specimen of Mr de la Beche they amount to 31, and of these 17 appear to be cervical or anterior false ribs, with single tubercles; thus affording another mark of resemblance to the SAURIAL family in osteological characters.

The bones of the head, distinguished by the extraordinary size of the orbit, are similar to those of the Saurial Reptiles. The *sternum*, collar-bone, and scapula, though also similar to those of this family, bear a much closer resemblance to the figure of these parts in the *Echidna* and *Ornithorhyncus*. The *humerus* is short, thick, and sinuated; the bones of the fore arm flat, and probably constituting part of the fore or thoracic fin. The *Carpus* consists of three rows, the first containing three bones, the other two, four each. These are followed by five or six rows of flattened, irregularly cuboidal bones, gradually diminishing in size and number to the tips, and which represent at once the *metacarpus* and *phalanges* of the fore paw, used apparently chiefly as a fin or paddle. The pelvic extremities appear to have been less strong and perfectly constructed than the thoracic. The *femur* is smaller and shorter than the *humerus;* the *tibia* and *fibula* are flattened like the *ulna* and *radius;* the *tarsus* consists of two rows only, the first containing three, and the second five bones; and this in like manner terminates in five ranges of flattened bones, gradually diminishing in size, and which represent the *metatarsus* and metatarsal phalanges of the hind paw or paddle.

and Plesiosaurus.

From the specimens hitherto discovered of the *Plesiosaurus*, it appears that the total number of vertebræ amounts to 90, of which 35 appear to be cervical, while the other 55 are dorsal and caudal, the regions of which are proportionally short. The head of this animal also is small and compressed, nor has it the large orbit of the *Ichthyosaurus*. Each rib consists of a vertebral and sternal portion, united at an obtuse angle, the former articulated by a single head to the transverse process, and the latter connected with its fellow by a transverse slip, so that the lower or abdominal ribs appear to have surrounded the abdomen with a complete cincture. The anterior part of the chest is occupied by two trilateral bones uniting in the middle, which, from their connection with the scapula, are believed to be the coracoid bones; and above these is a transverse piece, with a middle notch and lateral sinuated elevations, which is regarded as the *sternum;* while the *scapula* extends on each side like a buttress between the two. It is not improbable, nevertheless, that the middle portions named coracoid bones are the sternum, and the transverse bone the clavicles; and it is worthy of remark, that not only this bone, but the middle piece, closely resembles in figure and disposition those of the *Echidna* and *Ornithorhyncus*. The *pelvis* consists of three bones, a vertebral or superior, corresponding to the *ilium*, narrow and slightly incurvated; an anterior, ascending forwards, and broad, separating the *pubis;* and a posterior, short, forming the *ischium*. The humerus and femur are longer than in the *Ichthyosaurus*. There is a very short *radius* and *ulna*, and *tibia* and *fibula*, articulated with five carpal and tarsal bones; and the rest of both paddles consists of successive rows of flattened but long bones, contracted in the middle, and expanded at the extremities, representing the metacarpal and metatarsal digital phalanges. (Home, *Phil. Trans.* 1816, 1818, 1819, 1820; De la Beche and Conybeare, *Geological Transactions*, vol. v. p. 559; and Cuvier, *Ossemens Fossiles*, vol. v. part ii.)

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SECT. IV.—OSTEOLOGY OF THE FISHES.

The SERPENTINE or OPHIAD Reptiles present in their osteological characters an approximative transition to those of Fishes. While in the former order the skeleton is reduced to the spinal column, ribs, and head, in the latter class the spine and head only are left; and in some tribes the transition is still more distinctly marked by the presence of ribs.

Vertebræ

The vertebra of a fish is distinguished from that of any other animal by the shape of its body. The cephalic and caudal, or anterior and posterior surfaces, are hollow cup-like cones, so that the union of each two vertebræ forms a double conical cavity, united by the base, containing a substance composed of concentric fibro-cartilaginous layers, with intermediate albuminous or gelatinous matter. By this cartilage the vertebral bodies are united; and on this the motions of the spine are effected. This motion, however, is chiefly lateral; for the spinous processes are so long, and the articulation so complex, that antero-posterior inflection or extension is nearly impracticable.

In the cartilaginous fishes, for instance the shark, sturgeon, and lamprey, the vertebral bodies form simple tubes, which, from the extreme elasticity of the constituent cartilage, propel the contained fluid to a considerable distance. Thus Sir E. Home saw the fluid projected to the height of four feet from the intervertebral cavities of the shark. (*Phil. Trans.* 1809.) In this order, also, the spine is infinitely more flexible, and its resilient power, when bent by the muscles, is almost incredible. On each side, also, the vertebræ are excavated, to form a canal for lodging the large blood-vessels.

The vertebræ of fishes are numerous, and not easily distinguished into classes. They may, however, be distinguished into two, according as the spinous process is above only, or above and below at once. Those with the dorsal spine only are denominated *dorsal or abdominal vertebræ*, and have commonly at the sides transverse processes for the attachment of the ribs. Those with the dorsal and ventral spines are distinguished as the *caudal vertebræ*. The last caudal vertebra is generally trilateral, flattened in the vertical direction; and its tip is marked with articular pits, which indicate the attachment of the small elongated bones which sustain the caudal fins.

The number of vertebræ varies. In the *uranoscopus* or star-gazer there are only 25, in the *balista* 17, and in the four-spined trunk-fish (*ostracion*) only 13; while in the sturgeon the number is 84, in the eel 115, and in the shark 207.

Though FISHES have no chest, and require none, since their respiratory organs are gills, all of them are not void of ribs. The ray, shark, *syngnathus*, *tetraodon*, *diodon*, *cy-*

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clopterus, *fistularia*, &c. have indeed no vestige of rib. But in the sturgeon, *balista*, eel, *uranoscopus*, *pleuronectes*, sea-wolf, and dory, they are in the shape of short rudimental processes; in the *trigla* and *loricaria* their sides are horizontal; in the perch, carp, pike, and *chetodon*, they encompass nearly the whole upper region of the abdominal cavity; and, lastly, in the silver-fish (*zeus vomer*), the herring, rhomboidal salmon, &c. they are united to a sternum. In the little animal named sea-horse (*syngnathus hippocampus*), several series of osseous tubercles of the skin, surrounding the body like belts, are supposed to represent false ribs. The sternum is limited to a small number of FISHES. Besides those already mentioned, in the dory there is a series of minute flat bones disseminated along the lower edge of the belly, which is supposed to represent a rudimental sternum.

The head. Cranium.

In size and number the ribs vary, though in the *silurus*, carp, and *chetodon* they are of largest proportional size; in the herring they are as fine as hairs.

The head in the finny tribes is more an object of zoological than anatomical description. The chief points to be remarked are, that the cranium forms but a small part of the head; that the orbits are separated by a *septum*, sometimes membranous, occasionally, as in the wolf-fish, bony; and that there is on each side a large movable bone, corresponding to the quadrilateral of BIRDS, not square, however, but oblong, which supports not only the lower jaw and palatine arches, but the gill-cover. In the cartilaginous fishes the sutures are early obliterated, and the cranium consists of an inseparable mass of cartilage. In the bony fishes the cranium is separable into numerous pieces, and in the perch they amount to 80. In the cranium of fishes the anatomist recognises more distinctly than in the superior orders the formation according to the vertebral type. Small in proportion to the whole head, the cranium appears like a direct continuation of the vertebral column. In the osseous division of the class especially, the cranium may be distinguished into the occipital or posterior vertebra, the spheno-parietal or middle, and the frontal or facial vertebra. The cavity thus formed is very small; yet small as it is, it is not exactly filled by the brain, between which and the bones there is interposed a pellucid fluid, contained in fine cellular tissue. The cranium of the osseous fishes also is widest between the ears, because the organ of hearing is contained within its cavity with the brain. In the cartilaginous it is quite different.

Locomotive members or fins.

Though FISHES are destitute of extremities similar to those possessed by the other three classes of the VERTEBRATA, they are not, however, without locomotive members. The thoracic extremities are represented by the pectoral fins, and the pelvic by the ventral. In short, it may be said that the bones of the thoracic and abdominal extremities are converted into osseous rays in the finny tribes.

Pectoral fins.

In the Ray *genus*, in which the wing-like disposition of the pectoral fins gives the body a rhomboidal shape, they consist of numerous radiating cartilaginous lines, all attached to a cartilage parallel to the spine, divisible into two or three others, and articulated above to another adherent to the spine. Below there is a strong transverse bar common to the cartilages of both fins, and separating at once the sternum and clavicle. This transverse bar is also seen in the shark tribe; but their pectoral fins, which are much smaller, are not articulated with the spine.

In the osseous fishes, and in many others usually referred to the cartilaginous division, *e. g.* the *balista*, the pectoral fins are fixed to an osseous belt, which surrounds the body behind the gills, and which supports the posterior margin of their aperture. This belt consists of a single bone on each side, articulated to the posterior-superior angle of the cranium, and uniting below the breast with that of the opposite side. This bone, which may be regarded as a *scapula*, varies in shape and the angle which it forms with its fellow in different species. In fishes flattened vertically, the angle of union is acute; in those which are depressed, the angle is so obtuse as to form nearly a straight line. In many fishes, especially those of the order THORACICI, *e. g. pleuronectes*, *cottus*, *zeus*, *chetodon*, perch, &c., in the small unicorn (*balista*), and others, the superior part forms a large spine, which descends immediately behind the fin, and to which the *adductor* muscles are attached. This spine, which is movable, has been improperly named a *clavicle*.

The rays by which the membrane is supported are not directly articulated to this belt, but are connected by a row of minute flat bones, which may be compared to the *carpus* in the other three classes. When the first ray of the pectoral fin, however, is thorny, as in the harness-fish (*loricaria*), and some species of *silurus*, it is articulated directly with an osseous belt; and it is remarkable that some fishes, as the *silurus* and stickle-back, have the power of retaining this spinous ray erected against the body as a means of defence. This is effected by a cylindrical tubercle, on which the spinous ray is articulated by a hollow, bounded before and behind by an elevated process. When the spine is erected, the anterior process, entering a hole in the cylindrical tubercle, is locked in it by the spine revolving slightly on its axis, so that it cannot be inflected unless by the spine revolving in the opposite direction.

Pterygoid pectoral fins.

The pectoral fins are so long that they answer the purpose of wings in several species of *trigla*, the *trigla hirundo*, the flying gurnard (*trigla volitans*), the springing gurnard (*trigla evolans*,) in the *scorpæna volitans*, the tropical flying fish (*exocœtus volitans*), and some others. Their situation also is liable to vary. In the *exocœtus* they are near the gills, but in the *blennius* and others they are remote. Lastly, they are totally wanting in a small number only, as the lamprey (*petromyzon*), the hag-fish (*myxine*, Lin.; *gastrobranchus*), the *muræna*, the eel *genus*, the *sphagobranchus*, &c.

Abdominal or ventral fins.

The abdominal or ventral fins, which correspond to the pelvic extremities of the other classes, are so denominated because in the majority of fishes they are situate below the belly, and nearer the anal outlet than the pectoral. By this circumstance a numerous order are distinguished by the name of Abdominal Fishes (ABDOMINALES).

In a small number of fishes, comprehending the *gadus*, *blennius*, *kurtus*, *callionymus*, *trachinus*, and *uranoscopus*, the ventral fins are placed under the throat, below the aperture of the gills, and before the pectoral fins. This order is therefore distinguished by the name of JUGULARES.

In the most numerous order of all, the ventral fins are situate behind and below the pectoral fins. These have therefore been denominated Thoracic Fishes (THORACICI).

The ventral fins consist of two parts—one formed of rays covered by a double membrane, apparent externally, and constituting the proper ventral fin; the other internal, representing the coxal bones of the *pelvis*, always supporting the pinnal rays, and often articulated with the bones of the trunk. It is never articulated, however, with the spine, nor does it form an osseous belt round the abdomen. The bones of which it consists are generally flattened, varying in shape, and in mutual contact by the internal margin. In the shark and ray *genera* only is there a single transverse bone, nearly cylindrical, to the extre-

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Ventral fins.

mities of which the fins are attached. The direction of the pelvic plane to the walls of the abdomen varies according to the shape of the body of the fish. In the flat fishes they are directed obliquely, and their inner margin forms the keel of the belly. In fishes with a broad or cylindrical belly they form a plane more or less horizontal.

In the JUGULAR and THORACIC FISHES, the pelvic bones are always articulated with the base of the belt which sustains the pectoral fins; and they vary much in shape and situation.

In the *trachinus, uranoscopus, cottus, sciæna, chetodon,* and perch, these two bones are united by their inner margin. In the cuckoo-gurnard, in which they are united by the posterior tip only of their internal margin, they are broad, flat, and oval. In the sole and flounder *genus* (*pleuronectes*), in which the fins are attached to their anterior tip, they are united in a quadrangular pyramid, the apex of which is directed backwards and upwards, and the base forwards. In some of the stickle-backs these bones are altogether separate, and being long, receive in their middle a movable spine, which supplies the place of the ventral fin. In the dory (*zeus faber*, L.) they are flat and triangular, in mutual contact by their whole surface. In the silver-fish (*zeus vomer*) they are small and cylindrical.

In the whole of the ABDOMINAL order, on the contrary, the pelvic bones are equally unconnected with the bones of the shoulder and with the osseous belt of the pectoral fins, and are confined to the middle-inferior part of the belly, not far from the *anus*. In general these two bones are separate from each other, and are retained in their situation by ligaments. In the carp, in which they are elongated, they touch only by their posterior third. In the herring, in which they are small and approximated, they are continuous with the minute bones of the sternum. In the pike they are broad and trilateral, approximated by their anterior tips, separate behind where the fin is attached. In the *silurus*, in which they are united, they form a round and often spinous shield before, while the fins are attached to the exterior-posterior margin. Lastly, in the cuirassier or harness-fish (*loricaria*), the pelvic bones are united in one piece, the posterior notch of which forms the anal aperture, while the fins are attached to its external margin.

The proper fin consists of a certain number of osseous rays, simple or bifid, supported by one or two rows of minute bones placed between them and the pelvic bones. On these small bones the constituent rays move, diverging or converging like the rods of a fan, while the whole fin may be inflected or extended by the minute bones moving on the pelvic, so as to adduct or abduct the fin.

In the cartilaginous fishes the structure is different. To the tip of each pelvic bone are articulated two principal cartilages, one external, forming a kind of toe with seven or eight joints; the other internal, supporting all the other rays of the fin, which often exceed thirty in number.

Analogy or unity of principle in organisation.

If we suppose these bones, like the minute ones of the pectoral fin, to represent the *tarsus* of the other three classes, it must follow that, in the locomotive extremities, the *humerus*, with the *ulna* and *radius*, and the *femur*, with the *tibia* and *fibula*, are obliterated. It is not unimportant to observe, that the general structure of the VERTEBRATA tends through various transitions to this termination. In the AMPHIBIA the long bones of the extremities are shortened by removing the *diaphysis*, and leaving their articulating ends only. In the CETACEA the pelvic extremities are removed altogether. In the CHELONIAD and SAURIAL REPTILES the same long bones of the extremities are much abridged; and in the ICHTHYOID REPTILES, now extinct, but sharing by their structure a form of animal existence partaking of the reptile and fish at once, and perhaps intermediate between the two, this abbreviation is carried perhaps to its greatest possible degree, in leaving the articular ends only of the four locomotive extremities. Lastly, this reduction is merely preparatory to that exhibited in the whole class of FISHES, in which the three longitudinal bones so conspicuous in the higher classes of animals are completely obliterated, and those representing the hand or forepaw and foot are articulated directly to the shoulder and pelvic bones.

Besides the bones already mentioned as constituting the skeleton, there are observed in the osseous fishes minute bones, generally fork-like in shape, disseminated through all the muscular parts of the body. The purpose of these bones, which, as being totally insulated from the other parts of the skeleton, are denominated *ossicula musculorum*, is chiefly to afford points of support; and they are probably to be regarded as rudimental representatives of osseous parts, more completely developed in the higher animals.

Violation of the law of symmetry.

It is further a curious circumstance, that the skeleton, which is so symmetrical in all the other classes and orders, begins to exhibit a deviation from this first in the skeleton of the finny tribes. In the Sole *genus* (*Pleuronectes*) this deviation is very conspicuous. Both eyes are placed on the same side of the mesial plane; and the side on which the eyes are placed is broader than the opposite one. The former is bounded by a convex margin, the latter by a concave one. The orbit towards the former is large, the other small and imperfect. Conversely, it is to be observed, that in the latter the maxillary and intermaxillary bones are larger than in the former. The sides of the inferior jaw are less discordant; and though in the Sole and Plaice those of the eyeless side are more straight and elongated than those of the other, in the Turbot (*Pleuronectes maximus*) they are nearly symmetrical.

CHAP. II.—COMPARATIVE MYOLOGY.

Though this is the proper place to consider the peculiarities of the muscular system of animals, the limits assigned to this sketch will not allow us to enter into details. We shall merely, therefore, take a cursory view of those points in which the myology of the lower animals differs from that of the human subject.

In general, in the lower animals, especially the MAMMALIA, BIRDS, and REPTILES, the muscles correspond in situation to those of the human subject; and whatever modifications they undergo consist in changes of figure, and in some few instances in changes in attachment. The former kind of changes may be in all cases pretty accurately estimated by the osteological characters of the class, order, or genus; for when the position, shape, or direction of a bone is altered, in the same proportion nearly are the attached muscles altered in their attributes.

Deficiency in number.

Though in the lower animals, however, the zootomist traces muscles in general quite analogous to those of the human subject, in several instances this analogy ceases to be observed. In general the muscles of the lower animals are less numerous than those of the human subject; and this deficiency in number, though not much observed in the QUADRUMANA, is very remarkable in all the inferior orders of the MAMMALIA, and still more in the BIRDS and REPTILES. In general, also, these variations are most conspicuous in the locomotive extremities. Thus the small pectoral muscle, which is present in the QUADRUMANA, is wanting in the CARNIVORA and the whole of the Ungulated Animals and the Reptiles. The short *supinator* is present in the Canine and Feline *genera*, but the long is wanting; and both are absent in the CHIROPTERA, RODENTIA, PACHYDERMATA, RUMINANTIA, and

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SOLIDUNGULA, and in the whole class of BIRDS. Both pronators (*teres* and *quadratus*) are present in the QUADRUMANA and CARNIVORA, but wanting in the CHIROPTERA, Ruminants, and SOLIDUNGULA. The Rabbit, and perhaps the RODENTIA generally, have the *pronator teres;* but as the radius is not very movable, its influence is trifling.

Myological peculiarities of the whole.

In the mole the *rhomboideus* is inserted into the cervical ligament, which is ossified; and it therefore elevates the head and neck on the *scapula* with singular force. This is effected still more remarkably by the occipital part of the *rhomboideus*, the fibres of which being parallel to the spine, pass below the proper *rhomboideus* to be attached to the transverse ligament and the middle of the *cranium*. The strong, thick, quadrangular collar-bone has two muscles, a *supraclavius* and a *subclavius*. The large pectoral is very thick, and nearly as large as in birds.

The common extensor of the fingers or fore toes is the only muscle which is common to man and all the quadrupeds. Of the proper extensors the horse has two on the side of the common extensor, but acting as an extensor of the fore pastern; another between the common extensor and the extensor of the pastern, and which seems merely an appendage to the former. The proper extensor of the index is wanting in the RODENTIA, Ruminants, and SOLIDUNGULA; and while the two latter orders are destitute of the long and short extensors of the thumb, and the feline, canine, ursine, and leporine *genera* have the former, they are destitute of the latter. Lastly, the lower animals are wholly destitute of the short muscles of the hand, which in man produce flection, abduction, adduction, and opposition. In the CHIROPTERA only is there one extensor, and flexors of the fore toes.

Among the muscles of the pelvic extremities the *glutæus maximus*, or large muscle of the buttock in man, diminishes much in the QUADRUMANA; and in the other orders is reduced to a very small size. The buttock in the MAMMALIA generally consists chiefly of the *glutæus medius* and *minimus;* and while the *glutæus maximus* is in the horse in a great part aponeurotic, the *g. medius* is so large as to produce those forcible and sudden extensions of the hind leg which constitute the kick.

In the leg the *sartorius* of the horse, the animal in which the muscles have been most studied, is large, and is distinguished by the name of the long *adductor*, in opposition to the *gracilis*, which constitutes the short *adductor*. The muscle representing the *biceps* of man is in all quadrupeds a *uniceps*, and the single head is attached to the ischium only. In the horse and dog it has been denominated the *vastus longus*.

The *gastrocnemius externus et internus* (*gemellus*), which constitute the calf of the human subject, diminish considerably in the lower animals; and the *solæus*, which is placed below them, also becomes small, and is particularly slender in the Ruminants and SOLIDUNGULA.

Muscles wanting in birds.

The following muscles are wanting in the whole class of BIRDS. The diaphragm, the *recti abdominis*, and the *pyramidales;* the muscles of the dorsal part of the spine, the *splenius*, the *brachialis externus*, or third head of the *triceps;* the supinators of the fore arm or wing, as already mentioned, all those corresponding to the short muscles of the hand and fingers; the *quadratus lumborum*, the *psoas parvus*, the *psoas magnus*, *iliacus internus*, *obturator externus*, and the *extensor longus pollicis pedis*.

Two muscles, which occupy the situation of the pronators, act as flexors, showing the connection between the actions of inflection and pronation, and the occasional substitution of the latter for the former.

In this class, also, the *glutæus maximus* is of a pyramidal shape, while the true *pyriformis* is wanting. The *glutæus minimus*, which is attached to the anterior edge of the iliac bones, is the *iliacus*. In place of the *pectineus* there is a slender muscle, which extends to the knee, over which its tendon passes, and gliding behind the leg, its tendon is bifurcated, one slip going back to be inserted into the posterior part of the metatarsus, the other to be united to the perforated flexor of the first and last toe. This muscle, which is named the *accessory femoral flexor*, is the one by which birds are enabled to clasp a perch during sleep.

Muscles used in flying.

In BIRDS the great pectoral is a remarkable muscle in point of size. It consists indeed of three muscles, the large pectoral, the middle, and the small, which occupy the sides of the vertical crest of the sternum, and constitute what is named the breast of the animal; and which are chiefly employed in the energetic motion of the wings in flying. These muscles are sometimes so large that they weigh more than all the other muscles of the animal together. In birds which fly much they are dark coloured and firm; in those which fly little, as the domestic poultry, they are white coloured, and in general soft. The same distinction is observed in the muscles of the two extremities. In birds much on the wing these muscles are dark coloured and firm, while those of the legs are comparatively lighter and more tender; and, conversely, in birds little on the wing and mostly on the legs, as the domestic poultry and many of the *Grallæ*, the waders, swimmers, &c. the muscles of the wings are light coloured and tender, while those of the legs are dark coloured, firm, and strong.

Mechanism of perching.

The flexor muscles of the leg and toes of BIRDS merit notice. They consist of muscles corresponding to the long flexors, which are divided into three masses. The first consists of five portions, three of which may be regarded as constituting a single *common perforated flexor*. It rises by two bellies, one attached to the external condyle of the *femur*, forming a perforated tendon, which receives one of those of the muscle corresponding to the *peronæus;* the other to the posterior surface of the femur, forming the tendons of the index and small toe. This muscle is further connected by intermediate fibres with the accessory femoral flexor,—a muscle placed on the internal surface of the thigh, and sending its tendon over the knee; and as the tendons are inserted into the unguinal phalanges, when the accessory femoral bends the thigh the flexors of the toes inflect them also, and retain them in the inflected position. By means of this arrangement birds are enabled to clasp a perch or other small body when roosting, without continued muscular effort, and thereby to sleep on the perch. This mode of explanation, which was originally given by Borelli, has been controverted by Vicq d'Azyr; but apparently not on good grounds.

Among the class of Reptiles, while the muscles of the OPHIDIAL family are confined to those of the vertebræ and rudimental ribs, in the CHELONIAD these are obliterated, and the muscles of the neck, head, and tail, and those of the locomotive extremities alone, are left. In the other two classes of reptiles the muscles are in general analogous to those of the MAMMALIA.

Cutaneous muscle.

There are not many instances of muscles which, though unknown in man, are found in the lower animals. Of these the most remarkable are the cutaneous muscle (*panniculus carnosus*), and the suspensory of the eye. The former was absurdly maintained to exist in the human subject, especially by Nicolaus Massa; but it is manifest that the assertion was derived from the dissection of the lower animals only. It was not long after demonstrated by Charles Etienne, that no fleshy pannicle or cutaneous muscle exists, such as is found in the lower animals; and

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that the only cutaneous muscles in man are the *latissimus colli*, the *epicranius* or scalp-muscle, and those which are attached to the face, and which by their motion give expression to the countenance. The cutaneous muscle even is not found in the QUADRUMANA, nor does it exist in the pig. In various other animals, however, it is found in different degrees of distinctness. It is very well marked in the hedgehog and porcupine;—by its means they have the power of erecting their spines, and rolling themselves up;—and in the armadillo and the ant-eater tribe. In the mole, also, we have seen it pretty well marked.

Suspensory muscle of the eye proper to certain animals.

It is an interesting fact, that Galen originally observed that the lower animals possess a seventh muscle of the eye, or one more than man. The suspensory or infundibular muscle (*musculus choanoides*), as it has been named, from its shape, especially in the Ruminants and SOLIDUNGULA, has the *apex* fixed to the margin of the optic hole, and its base inserted a little behind the four straight muscles. In the ZOOPHAGA and CETACEA it consists of four parts, so that these orders appear to be provided with 8 straight muscles. In the rhinoceros it consists of two portions.

Tail,

There is yet another part, the muscles of which can scarcely be said to exist in the human subject, but which attain a very great degree of developement in the lower animals. The *coccyx* of the human subject is expanded in the lower animals into a highly flexible prolongation denominated the tail (*cauda*), variable in length, but always consisting of separate vertebræ, articulated and movable on each other. While the *coccyx* of the human subject possesses two muscles only, the *ischio-coccygeus* and *sacro-coccygeus*, which are so insignificant in size that they scarcely serve to move the part, the caudal vertebræ of the lower animals are moved by muscles greatly larger, more numerous, and more powerful.

The tail is to animals a much more useful and powerful organ than the coccyx to man. It is a member which peculiarly belongs to them; and though in ordinary circumstances pendulous, it is made to assume a variety of motions of which no other organ is susceptible, and to perform duties which would be otherwise impracticable. With many, as the long-tailed monkeys, the sloths, the ant-eater, and the squirrel tribes, it is indispensable as an organ of prehension. The majority of animals, as the Ruminants, SOLIDUNGULA, &c. use it as a whip or lash to drive away insects. The lion, tiger, and others of the feline tribe, lash their sides with it when enraged. The Cetaceous swimmers employ it as a rudder and oar in the waters. The beaver uses it as a trowel, to enable him to construct his clay-built dwelling. An organ employed so variously must consist of a muscular apparatus rather complex.

and caudal muscles.

The different motions of which the tail of the MAMMALIA is susceptible may be referred to three heads,—one by which it is extended or elevated, another by which it is inflected or depressed, and a third by which it is made to beat the sides. The combination or succession of these motions gives rise to secondary ones more complex in character. It may be twisted on its axis, or turned in a spiral direction. These motions are effected by three classes of muscles.

1*st*, The muscles which raise the tail are situate above; they are *musculi sacro-coccygæi superiores*. Commencing at the base of the articular processes of the 3 or 4 last lumbar vertebræ, or those of the sacrum and the caudal vertebræ, by fleshy slips, they are connected to tendons, which are inserted into the base of the first of the caudal vertebræ, which are void of articular processes. The second tendon goes to the next following vertebra, and so on to the 13th, each contained in a ligamentous groove, which forms an investment. The muscles of both sides acting together, elevate or incurvate the tail upwards.

The *interspinalis* and *spinalis obliquus* or lumbo-sacro-coccygeal are the continuations of the *interspinales dorsi et lumborum*. The spinous processes, however, becoming indistinct, or being represented by two tubercles, the attachments vary.

2*d*, The muscles which depress or inflect the tail downwards take their origin within the pelvis, and are prolonged to various extents along the inferior surface of the tail. Of these there are four pairs, the *ileo-coccygeal* of Vicq d'Azyr, the inferior *sacro-coccygeal*, the *inter-coccygeal* muscles, and the *pubo-coccygeal* of the same author. The insertions of these muscles vary in different genera, according to the number of vertebræ of which the tail consists. The pubo-coccygeal is wanting in the raccoon, but it is distinct in the dog and opossum. The effect of the ileo-coccygeal and it, is to depress the tail and apply it forcibly to the *anus*.

3*d*, There are only two muscles which carry the tail to the sides of the animal—the *ischio-coccygæus externus*, and the *intertransversalis* of Vicq d'Azyr; the former proceeding from the pelvic surface of the *ischium* below and behind the *acetabulum*, to the transverse processes of the caudal vertebræ, the second extending in a continued band between all the transverse processes.

The tail, therefore, in the MAMMALIA, consists of a series of successively decreasing vertebræ, moved by eight pairs of muscles.

In FISHES it is not easy to trace any analogy between the muscles and those of the other classes. Though the spine, head and fins, have appropriate muscular bundles, the natural or fascial distinctions are less evident than in the other three classes. It is important, however, to remark, that while the muscles which move the spinal column are placed in these classes, partly before, and chiefly behind the vertebræ, those of FISHES are placed on each side. Hence the lateral motion of the spine, which is inconsiderable in MAMMIFEROUS animals, BIRDS, and REPTILES, becomes very conspicuous in the finny tribes, especially in the motion of swimming, while the antero-posterior inflection or extension is altogether insignificant.

It is almost superfluous to remark, that, in the greater part of the finny tribes, the muscles are white or pale coloured. In a few only, for instance the salmon, trout, gwiniad (*coregonus*), herring (*clupea harengus*), carp (*cyprinus*), and some others, are the muscular fibres of a pale flesh red. The circumstances on which these differences depend are not known; but it is supposed that in the latter sorts the proportion of oleo-albuminous matter is more abundant than in the former. The proportion of albumen, however, in the muscles of fish, seems in general to be small. They abound in gelatine and isinglass; and in some of the cartilaginous fishes especially, the greater part of the muscles seem to consist chiefly of gelatine in various degrees of consistence. This is particularly the case with the lamprey, the hag-fish (*myxine glutinosa*), and even with the sturgeon. The sterlet especially (*acipenser Ruthenus*), a small species of sturgeon found in the rivers of Russia, both European and Asiatic, abounds in gelatine; and the presence of this principle enables the inhabitants to use it in the preparation of a species of soup, the sterlet, which is esteemed a great delicacy. In some of the *genus Pleuronectes* this principle is also very abundant. Thus the Plaice (*Pleuronectes Platessa*), sole (*P. Solea*), and especially the turbot (*P. Maximus*), contain a considerable proportion of gelatine. On the proportion of this principle depends the quality of fish used

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as an article of food in nourishing without exciting. All fishes which abound in gelatine uncombined with oleo-albuminous matter may be safely used as articles of food; while those in which the latter ingredients predominate are invariably eaten with the risk of disordering the stomach and producing indigestion.

CHAP. III.—COMPARATIVE ÆSTHIOLOGY, OR THE COMPARATIVE ANATOMY OF THE ORGANS OF SENSATION.

SECT. I.—THE ORGAN OF SMELL.

The organ of smell consists of the nasal cavities, those of the ethmoidal and turbinated bones, and the frontal, sphenoidal, and superior maxillary sinuses, all of which communicate with the nasal. The whole of these parts are invested by fine periosteum, lined by mucous membrane. The ethmoid bone is the essential organ of smell; and the others appear simply to multiply the extent of the membrane.

Ethmoid cells.

The ethmoid bone consists of a perforated plate, with a middle vertical one attached at right angles to it, and lateral portions composed of thin bony plates convoluted with various degrees of complexity and minuteness in different orders and genera of animals. These convoluted plates form what are denominated the ethmoidal cells. They may be represented as numerous tortuous canals, proceeding from the perforated plate forwards and outwards, approximating mutually, and forming numerous communicating cavities. Such nearly is the structure of these plates in the EDENTATA, RUMINANTIA, SOLIDUNGULA, PACHYDERMATA, and CARNIVORA, the last of which have more complicated cells than the first. In the dog they are numerous and extensive. In the RODENTIA, for instance the porcupine, they are few—not above 3 or 4 on each side.

In BIRDS the internal side of each nostril is occupied by three orders of plates; the inferior turbinated or spongy bone; the middle, consisting of one plate convoluted on itself two turns and a half; and the upper, shaped like a bell, adhering to the frontal and lacrymal bones. These form three tortuous passages, varying in size and tortuosity in different *genera*. Though generally cartilaginous, these turbinated bones are membranous in the cassowary and albatross, and bony in the calao and toucan.

In the nostrils of REPTILES there are convoluted prominent plates, which, however, are merely membranous productions, unsupported by any bone.

In the FISHES, in like manner, there are membranous folds, the disposition of which is tortuous. They are, however, more regularly arranged than in the other classes. In the cartilaginous fishes they consist of semilunar folds placed in parallel tracts on each side of a broad plate, which divides the one side of the nasal cavity from the other. In the sturgeon, however, they are arranged in diverging plates, which are subdivided into more minute ones, like the branches of a tree. In the osseous fishes generally they consist of radiating plates disposed round a prominent central tubercle.

In these three classes the olfactory nerve is distributed to the membrane much in the same manner. This nerve, however, does not proceed farther than the superior turbinated bones; and the middle and inferior appear to be supplied with filaments of the fifth pair, the naso-ophthalmic branch of which is distributed to the nose in all the vertebrated animals. In the MAMMALIA, further, the spheno-palatine ganglion sends several filaments to the posterior part of the narine membrane.

By most zootomical authors the trunk of the elephant has been described as an organ of smell peculiar to that animal. We are satisfied, however, from observing the motions of this body in the living animal, that it is an organ, not of smell, but of prehension. Cuvier, after adopting the ordinary view, has relinquished it, and, on the ground of personal inspection, admits that the sense of smell in the elephant is confined, as in other animals, to that portion of the nasal cavities which is contained within the bones of the head. The trunk of the elephant, therefore, will with greater propriety be noticed under a subsequent head.

The nasal cavities of the CETACEOUS animals are not so much organs of smell as channels of respiration, and must also be noticed afterwards. It is sufficient here to remark, that in these animals the part of the cranium corresponding to the ethmoid bone is penetrated by no aperture, or, in other words, is not an ethmoid bone. It has therefore been asserted that the CETACEA have no olfactory nerve, and no sense of smell. This, however, is by no means established. Blainville and Jacobsen have observed in the dolphin nerves which they regard as olfacient; and Treviranus delineates nerves of the same character. By Otto and Rudolphi, on the contrary, who have had frequent opportunities of dissecting the dolphin and whale, the existence of these nerves is denied.

Smell in invertebrated animals.

Though almost all the invertebrated animals give proofs of the existence of the sense of smell, in none of them do we find any organ in which this sensation appears with certainty to be exercised. That these animals possess the faculty of smell, is inferred from the fact, that insects recognise their food at a distance; that male butterflies scent the female even when inclosed in cages; and that the ordinary flesh-fly deposits her eggs on tainted meat, and occasionally on fetid plants, in the belief that they are the proper *nidus*, though in the latter case the *larvæ* perish for want of the necessary sustenance.

Since odorous particles are evidently applied to the olfactory membrane of all aeropnoic animals by the medium of the atmosphere, and since the organ of smell is therefore situate in connection with the wind-pipe, it was conjectured by Baster, that, in insects at least, the organ of smell is situate at the entrance of the *tracheæ* or air-tubes. This conjecture derives some probability from the fact, that the inner tracheal membrane in these animals is soft and moist, and that those in which it is expanded into convoluted *lacunæ* and tortuous vesicles, for instance beetles, flies, and bees, are remarkable for the nicety of their sense of smell.

The *antennæ*, in which this sense has been placed by some anatomists, appear to be rather organs of touch than of smell.

In the MOLLUSCA the whole cutaneous covering seems to combine the character of an organ of touch or tact, and of smell. Like an extensive pituitary membrane, it is soft, villous, moist, and liberally supplied with nerves. The ARTICULATA and Zoophytes seem much in the same state. But on all these points information is rather conjectural than positive.

SECT. II.—THE EYES; THE ORGANS OF VISION.

All red-blooded animals, without exception, are provided with two movable eyes, consisting of the same essential parts as those of man, forming globular organs, and placed in the cranio-facial cavities named orbits. In none are there more or fewer; and the exceptions to the general rule, either in relation to the presence of these organs, or number, are only apparent. Among the MAMMALIA, indeed, there are two instances of blindness,—in the *zemni* or blind rat (*Mus typhlus*, Lin.; *Spalax typhlus*, Pall.), and the golden mole (*Talpa Asiatica*, Lin.; *Chrysochloris*, Lacep. and Cuvier). But in neither of these animals are

Blind though not eyeless animals.

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the eyes absolutely wanting; they are merely very minute, and covered by a thin fold of hairy skin, in which there is said to be no aperture. Much in the same manner the *muræna coecilia*, and the hag-fish (*myxine*, Lin., *gastrobranchus cæcus*), though provided with eyes, are deprived of the use of these organs by the opacity of the *conjunctiva*. In the *Anableps* (*Cobitis Anableps*, Lin.), the *cornea* and *iris* are biparted by transverse bands, so as to give the animal the appearance of having two pupils in each eye, though the crystalline lens, vitreous humour, and retina, are single. This animal affords the only example of this structure among the vertebrated animals; but a similar arrangement is observed in the Cephalopodous MOLLUSCA and cuttle-fish family.

Figure of the eyeball.

The general shape of the eye depends on the medium in which the animal lives. It is nearly spherical, or approaching the spherical shape, in man and the quadrupeds moving along the surface of the earth; that is, in the lowest and most dense region of the atmosphere. The *cornea* merely forms a slight convexity, in consequence of being the segment of a smaller sphere than the rest of the eyeball; yet in the porcupine, opossum, &c., this difference is inconsiderable. To show the degree of this convexity, it is merely requisite to compare the axis or antero-posterior diameter with the transverse diameter of the ball, as exhibited in the following table:—

Axis and diameter.

	Axis.	Tr. Diam.		Axis.	Tr. Diam.
Man and ape	137	136	Whale	6	11
Dog	24	25	Porpoise	2	3
Horse	24	25	Owl	13	12
Ox	20	21	Vulture	13	16

According to the measurements of the younger Soemmering, the axis of the human eye, taken in a beautiful Tyrolese girl of 20, is to the transverse diameter as 100 to 95; that of the eye of the magot (*simia inuus*) as 85 to 84; and that of the bat (*vespertilio auritus*) as 12 to 11. In the raccoon (*ursus lotor*) and lynx (*felis lynx*) alone the axis is exactly equal to the diameter. In all the other vertebrated animals, it is, as in the measurements of Cuvier, less than the transverse diameter at the rate of from 9 to 33 or 45 per cent. In the horse it is as 186 to 212, in the seal as 130 to 142, in the Indian elephant as 135 to 180, and in the black whale (*balæna mysticetus*) as 20 to 29. In the owl it is as 17 to 18, in the golden falcon as $14\frac{1}{2}$ to 16, in the ostrich as 18 to $19\frac{1}{2}$, and in the swan as 7 to 10. In the REPTILES and FISHES it is always less at the rate of from 3 to nearly 10 per cent. In the cuttle-fish, which may be taken as a general example of the invertebrated classes, it is much greater, the axis being to the diameter as 80 to 57. (D. W. Soemmering *de Oculorum Hominis Animaliumque Sectione Horizontali Commentatio.* Goetting. 1818, fol.)

In FISHES and the CETACEA which inhabit the sea, the anterior part of the eyeball is much more flattened, and in many fishes it resembles a hemisphere with the plane surface before and the convex behind. In the ray *genus* the superior part is also flat, so as to give the eye the appearance of the quadrant of a sphere, cut through two large circles perpendicular to each other. In some fishes, especially the burbot (*Gadus Lota*), the *cornea* is convex.

In BIRDS which occupy the elevated regions of the atmosphere, the deviation from the spherical shape is in the direction opposite to that of fishes. On the anterior part, which is sometimes flat, sometimes shaped like a truncated cone, is chased a short cylinder, closed by a very convex, and occasionally hemispherical *cornea*, always belonging to a much smaller sphere than the posterior convexity.

Aqueous humour.

These differences in shape depend on the proportion between the density of the medium in which the animals live and that of the aqueous humour. In the higher regions of the atmosphere, in which the air is very much rarefied, the refracting power of the aqueous humour is much more considerable than at the surface, occupied by quadrupeds; and hence it is more abundant in the former than in the latter class. Its refracting power, however, would be almost extinguished in a watery medium, from which it could differ but little in density; and hence it is either trifling or absolutely wanting in the inhabitants of the deep. In the cuttle-fish family it is entirely wanting.

The crystalline lens in FISHES, which is nearly spherical, projects through the pupil, and leaves little room for the aqueous humour. The lens is also very convex in the CETACEA, the AMPHIBIOUS MAMMALIA, the diving birds, as the cormorant, and the marine and aquatic REPTILES.

Affecting the oblate spheroidal shape in the MAMMALIA, it becomes extremely so in man, and still more in BIRDS. Its consistence is greatest in animals in which it is most convex; and hence it is matter of common observation, that the crystalline of fishes is particularly firm. It also contains rather more albumen than the lens of the MAMMALIA. The crystalline lens occupies least proportional space of the eyeball in man, and most in fishes.

The comparative spaces occupied by each of the humours may be understood from the following table, in which the axis of the eye, or the space occupied by the whole three humours, is represented by unity.

	Aqueous Humour.	Crystalline Humour.	Vitreous Humour.
Man	$\frac{5}{22}$	$\frac{4}{22}$	$\frac{13}{22}$
Dog	$\frac{5}{21}$	$\frac{8}{21}$	$\frac{8}{21}$
Ox	$\frac{5}{37}$	$\frac{14}{37}$	$\frac{18}{37}$
Sheep	$\frac{4}{17}$	$\frac{11}{17}$	$\frac{12}{17}$
Horse	$\frac{9}{43}$	$\frac{16}{43}$	$\frac{18}{43}$
Owl	$\frac{8}{27}$	$\frac{11}{27}$	$\frac{8}{27}$
Herring	$\frac{1}{7}$	$\frac{5}{7}$	$\frac{1}{7}$

On the proportion of the total volume occupied by each of the three transparent parts there are few accurate facts. It may be remarked, however, that the human eye among the MAMMALIA is that in which the vitreous humour is proportionally most abundant. It is estimated to be twenty times more copious than the aqueous. In the ox it is only ten times, and in the sheep nine times the quantity of the aqueous.

Sclerotic.

In the MAMMALIA generally, the sclerotic is comparatively elastic, soft, and yielding; but in all animals in which the eye deviates from the spherical shape, as the CETACEA, FISHES, and BIRDS, this membrane is strengthened by greater solidity and thickness of tissue, or supported by accessory parts of a hard unyielding structure.

In the eye of the whale these two parts, the hard and soft, are naturally distinguished in a very striking manner. The lateral parts of the sclerotic are nearly an inch thick, and very hard. The posterior part is about one and a half inch thick, and softer, because the spaces between the firm fibres are filled with oily substance. The posterior part presents for the optic nerve a canal one and a half inch long, the walls of which are formed chiefly by fibres in direct continuity with the *dura mater*,—the only fact, it may be observed, which favours the statement of the ancient anatomists, that the sclerotic is derived from the *dura mater*. The sclerotic of the porpoise, though only two or three lines thick, has the same structure as that of the whale. In the seal it is thick before and thicker behind, but the middle zone is thin and flexible.

Osseous zone of birds.

The sclerotic in BIRDS is thin, flexible, and elastic behind, with a bluish glistening aspect, and without distinct fibres. The optic nerve enters, not by a hole, but an oblique canal. The anterior part consists of two plates, between which is enchased a zone of thin, hard, oblong, osse-

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ous scales, varying in number from 11 or 12 to 14 or 15, imbricated over each other so as to give the anterior part of the eyeball a great degree of hardness, and a figure unsusceptible of change. Though these plates are nearly flat in most birds, and form an annular zone slightly convex, they are broad, arched, and concave internally in the owl *genus*, and form a bell-shaped tube, with the posterior aperture oval and the anterior round. This may be denominated the osseous ring (*annulus osseus, zona ossea*). In the ostrich it is narrow and flat.

and reptiles.

Among the REPTILES, the CHELONIADS possess an osseous zone, consisting of plates inclosed in the membrane without being continuous with its substance. They are also found at the lateral part of the sclerotic in the chameleon and some of the SAURIAL Reptiles, as the *Crocodilus Sclerops* and *Lucius*, the monitor, and the iguana (D. W. Soemmering). It is also an important character in the structure of the eye of the Ichthyosaurus, which indicates the connection of that animal with the SAURIAL tribe, that its sclerotic was provided with an osseous zone, consisting, as in these, of 13 separate pieces.

In FISHES the sclerotic is cartilaginous, homogeneous, semi-translucent, elastic, and, though thin, firm enough not to collapse. In the ray it is expanded into a tubercle, by which the eye is attached to a peduncle or stalk. The sclerotic of the sturgeon is so thick that it resembles a cartilaginous sphere, with the external part hollowed for the humours and membranes.

In the CEPHALOPODOUS MOLLUSCA it forms behind a truncated cone, with the apex at the bottom of the orbit containing the gangliform swelling of the optic nerve, and several glandular parts, with the eye before.

Cornea.

The *cornea* has often been represented to be merely a continuation of the sclerotic; and though this is easily disproved by accurate dissection of the human eye and that of our ordinary domestic animals, its inaccuracy is much more manifestly demonstrated in the animal world at large. In the whale and rhinoceros the margins of the two membranes penetrate reciprocally. In man and the ox the corneal margin is enchased within the sharp imbricated edge of the sclerotic. In the tope-fish (*squalus milandra*, Lin.; *galeus*, Cuv.) the cornea is observed distinctly passing within the sclerotic in the manner of imbrication. The cuttle-fish is destitute of cornea; and as there is no aqueous humour, the crystalline lens is covered by a fine thin membrane, extended beneath the conjunctiva.

Corneal conjunctiva.

In all animals provided with eyelids, the mucous membrane, after being folded behind the eyelids, is reflected forwards over the sclerotic and cornea, in the form of a thin, transparent membrane. In those void of eyelids, as most fishes are, the skin, passing into mucous membrane, is continued directly over the *cornea*, without forming any angular fold, and adheres strongly. This is very distinct in the eel, which may be flayed without leaving any trace at the site of the eyes, except a round, translucent spot. The same peculiarity is remarked in SERPENTS and in the cuttle-fish family. In the *zemni*, golden mole, blind eel, and hag-fish, it has been already stated that the cornea is covered by opaque mucous membrane.

Choroid coat and Ruyschian membrane.

The choroid coat exists in all animals yet examined. It is always very vascular. The inner layer, which has been distinguished by the name of *tunica Ruyschiana*, can scarcely be said to exist in man, small quadrupeds, and birds. In the large quadrupeds, however, especially the CETACEOUS animals, it appears in the form of a distinct simple membrane like *epidermis*. The lateral and anterior parts of the membrane are always invested by a semifluid, viscid substance, of different shades of black or brown black (*pigmentum nigrum*); chocolate brown in the hare, rabbit, and pig; deep red brown in some birds; and purple red in the *calmar*. The absence of this dark-coloured pigment, which is not unfrequent, is observed in *albinos*, both human and animal, for instance white rabbits and white mice. The transparency of the Ruyschian membrane then shows the choroid of its natural red colour; and the pupil is red and contracted, and the eye intolerant of light.

The tapetum or metalline membrane.

In the ZOOPHAGA, RUMINANTIA, PACHYDERMATA, SOLIDUNGULA, and CETACEA, the concave or inner surface of the Ruyschian membrane is diversified with colours of metallic lustre, more or less brilliant and something iridescent. In the ox it is of bright metallic green, changing to sky-blue; in the horse, buck, buffalo, and stag, it is a silvery blue passing to violet; in the sheep of a pale golden green, sometimes bluish; in the lion, cat, bear, and dolphin, of a pale gold yellow; and in the dog, wolf, and badger, of a pure white, surrounded by blue. This coloured part of the inner choroid surface, which occupies chiefly the side opposite to that on which the optic nerve enters, is named the *tapetum*. The use of it is by no means obvious. The explanation of Monro in reference to the *tapetum* of the ox, that it represents more distinctly to that animal the colour of his natural food, is not only frivolous, but inapplicable to the other *genera*.

The *tapetum* is wanting in all BIRDS and FISHES, excepting the ray, in which there is at the bottom of the eye a beautiful silvery-coloured space, produced by the transparency of the Ruyschian tunic, through which the tint of the choroid is seen.

The choroid gland of fishes.

In FISHES generally the choroid consists of two distinct separable membranes; the external, the proper choroid, white, silvery, or golden, very thin and not vascular; and the inner or Ruyschian, black, and consisting of a network of vessels. Between these two membranes is a body of a bright red colour, consisting of numerous tortuous vessels, convoluted and inclosed in pulpy filamentous tissue. Its general shape is that of a thin cylinder, encompassing the optic nerve like a ring, which, however, is incomplete at one side. This is the choroid gland,—a body about which there has been some difference of opinion, but which appears to be glandular rather than any thing else. Its vascular structure is well seen in the globe-fish, *perca labrax*, and cod, in which they are very large, and form numerous anastomotic communications. They are generally covered by a white, opaque, viscid fluid.

The choroid gland is wanting in the CARTILAGINOUS FISHES, the eye of which approaches more nearly to that of the MAMMALIA in this as in other circumstances. The choroid of the ray and shark *genera* is a threefold tissue of vessels, thick and consistent; the *tunica Ruyschiana* is very thin and semi-transparent; and between these is a layer of silvery matter with metallic lustre.

In the cuttle-fish genus, though between the sclerotic and choroid there are several glandular bodies, there are none between the choroid and Ruyschian tunic. The choroid is thick, soft, and vascular; the Ruyschian thin, firm, and dry; and though there is no *tapetum*, the whole interior surface of the eye is covered by deep purple, semifluid, viscid varnish.

Ciliary processes and circle.

Ciliary processes are found in all the MAMMALIA, BIRDS, several REPTILES, and even in the cuttle-fish among the MOLLUSCA; but they are wanting in almost all fishes.

The indented border of these processes is more distinct, and is converted into a genuine fringe in the large animals, as the ox, horse, rhinoceros, and whale, in which the angle applied to the capsule is more acuminated than in other animals. In the CARNIVORA, particularly the lion, the base of the plates is shorter in proportion to the other sides than in the previously mentioned animals, so that the opposite angle is more prominent; nor is the

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border indented. In all the species every third or fourth plate is shorter than the others, but without determinate order.

The ciliary plates of Birds are mere serrated *striæ*, without sufficient prominence to make them undulate in fluid. In the owl they are fine, closely set, and numerous; in the ostrich they are larger and more numerous; and in all, their extremities adhere firmly to the capsule of the lens.

In the tortoise the ciliary processes are so short that they are recognised only by the impression left on the vitreous humour; in the crocodile, however, they are distinct, and terminate each by an angle nearly right. They are indistinct in the toad, and imperceptible in the ordinary lizards and serpents.

The ciliary body and processes are large and distinct in the tope-fish; but if they are seen in any other of the cartilaginous fishes, they are wholly wanting in the osseous, in which the Ruyschian tunic is directly continuous with the *uvea*.

The utility of these processes in retaining the lens in its position is nowhere so distinctly seen as in the eye of the cuttle-fish family, and especially the many-feet of the ancients (*polypus octopoda*). In these the ciliary processes form a large diaphragm or zone, in the aperture of which the crystalline lens is truly chased. They penetrate a deep annular furrow which surrounds the lens, dividing it in two unequal hemispheres, and cannot be detached without laceration.

The iris and uvea.

The *iris*, of the same intimate structure as in man, is of a deep tawny or brown in the Mammalia, and marked with fewer coloured *striæ* than the human *iris*. In Birds it is of a uniform lustreless colour, varying according to the species, bright yellow, red, or clear blue. In the microscope it appears like a net-work formed by the intersection of numerous very minute fibres. The *uvea* is so fine that when the viscid varnish is removed it becomes transparent, and the iris appears of the same colour on both sides. In Fishes, conversely, the *iris* is so thin and transparent that the *uvea* is seen through it, of a golden or silvery brilliance, showing its direct connection with the choroid. Intermediate in metallic splendour is the iris of the Reptiles. The vessels, however, are greatly more conspicuous, especially in the crocodile.

The central aperture or pupil, though round in man, the Quadrumana, many of the Carnivora, and Birds, is not of that shape when contracted in all animals. In the feline family it consists of two elliptical segments, which form angles above and below, and which approach mutually so as to form a slit nearly vertical. In the Ruminants it is oblong transversely, and forms at its greatest contraction an oblong or transverse slit. In the horse, in which it is also transverse, its upper margin is distinguished by a five-pointed festoon. In the whale it is oblong transversely, and in the dolphin it is heart-shaped. The pupil of the crocodile resembles that of the cat; in the frog and gecko it is rhomboidal; and round in the tortoise, chameleon, and common lizards. In the ray among Fishes the upper margin forms several radiating slips like the branches of the palm-tree, gold-coloured without, dark within. In the dilated state these slips are folded backwards between the upper margin of the pupil and the vitreous humour; but when the eye is pressed they are erected, and close the pupil like a blind.

The motion of the pupil is voluntary in the parroquet, and is indistinct in most of the Fishes.

The pupillary membrane is well known to exist in the fœtuses of all the Mammalia; but it is not determined whether it is found in the chick of birds.

On the subject of the retina in the lower animals the most important point is the structure of the melanoplectic or pectiniform membrane (*pecten, marsupium nigrum*) of Birds. In this class the optic nerve forms not a round disk as in the Mammalia, but a narrow white line, the margins and extremity of which are in continuity with the *retina*. Along this line is suspended a plicated or convoluted membrane, very fine and vascular in structure, like the choroid, from which, however, it is quite distinct, and entering a depression of the vitreous humour almost like a wedge. Its vessels, which proceed from a proper branch of the ophthalmic artery, are distributed in a minute arborescent form, among the folds of which the *marsupium* consists; and from these vessels the black viscid pigment with which its folds are covered appears to be secreted. The *plicæ* or membranous folds vary in number. In the cassowary they are only 4; in the brown owl (*S. aluco*) 5; in the common owl, ostrich, Guiana macaw, and merganser, they are 7; in the flamingo 9; in the falcon and swan 11; in the vulture and goose 12; in the duck, large heron, woodcock, and coot, 13; in the stork and partridge 15; in the crane 17; in the pheasant 20; in the turkey 22; in the jackdaw 25; and in the thrush 28. According to the observations of the elder Soemmering, to whom we are indebted for these numbers, the number of folds, though variable in different species, is the same in the same. In most birds the folds are arranged in a pectiniform order. On the use of this organ different opinions have been entertained by Petit, Haller, and Home; but all of them are conjectural.

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In the Reptiles and many Fishes, between the optic nerve and the *retina* is a small tubercle, from the margins of which the latter membrane appears to rise; and radiating fibres are perceived more distinctly than in most quadrupeds. In many other Fishes the connection of the retina with the optic nerves resembles that of Birds. Thus, in the salmon, trout, herring, mackarel, cod, dory, and moon-fish, the optic nerve, after passing through the Ruyschian tunic, appears to be parted into two long white processes, which, following the outline of this membrane parallel but not contiguous to each other, are connected with the *retina* by their opposite margins.

In all animals provided with ciliary processes the *retina* terminates at and is connected with the gray pulpy zone denominated ciliary ligament. In those without ciliary processes, as the Fishes, it terminates suddenly at the attached or large margin of the *uvea*.

In several of the reptiles the retina presents the yellow spot of Soemmering. The principal peculiarities of the humours have been already mentioned.

Of the appendages the most important are the lacrymal gland and nictitating membrane.

Lacrymal gland.

In the Ruminants the lacrymal gland consists of two or three bodies, each composed of granules, each provided with a separate short excretory duct. In the hare and rabbit, in which the gland is large, there appears to be only one excretory duct, which perforates the upper eyelid near its posterior angle.

A gland peculiar to certain species, and wanting in man, that of *Harder*, is situate at the external or nasal angle, and presents an aperture under the third or nictitating eyelid, from which issues a thick viscid fluid. It is found in the Ruminants, the Rodentia, the Pachydermata, and in the sloth genus.

The caruncle exists in the Ruminants as in man, and appears to consist of numerous aggregated follicles. It is wanting in the Rodentia.

In the Cetacea, as in most animals which live under water, there is neither gland nor lacrymal passages; and they are represented apparently by *lacunæ* below the upper eyelid, which discharge a thick mucilaginous fluid.

Birds, though destitute of caruncle, have both lacry-

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mal gland and that of Harder, the latter large, oblong, and flesh-coloured, placed betwixt the *levator* and *adductor*, and discharging by a single canal, opening at the inner surface of the third eyelid, a thick yellow fluid. The lacrymal, which is small, round, and very red, is provided in general with two or three canals, which, though small, are distinct. In most of the GRALLÆ and PALMIPED Birds there is, in place of the lacrymal gland, a hard granular body, occupying the upper part of the orbit, and following in situation the curvature of the eye. It has, nevertheless, no visible excretory duct.

Lacrymal follicles.

In the turtle there is a reddish granular lobulated body, of considerable size, extending beneath the temporal vault. In the tortoise, frog, and toad, there are two small blackish glands without apparent excretory ducts. Neither in Serpents nor FISHES has any glandular apparatus in the eye been recognised.

The third eyelid or nictitating membrane.

Though in man and the monkey tribe the eyelids consist of two semilunar cutaneo-muscular folds, with a minute mucous duplicature at the nasal angle, the latter acquires such a developement in the lower animals as to constitute a genuine third eyelid, often distinguished by the name of *nictitating membrane*. This duplicature is semilunar in shape in the Ruminants, EDENTATA, and PACHYDERMATA. In the rhinoceros it is thick and fleshy; but of this the CETACEA present no trace. In the BIRDS, on the contrary, in which the eye is covered by the elevation of the lower eyelid, which is also the largest, the third eyelid is large, and covers the eye like a blind drawn before it; yet it is in some degree translucent, for it is evident that birds see objects through the membrane. In the owl and goatsucker the eye is closed by the depression of the upper as well as the elevation of the lower eyelid.

Though the SERPENTINE reptiles are void of eyelids entirely, in the crocodile, tortoise, and BATRACHOID, there are three, as in birds, the third being vertical in the two former orders, and horizontal in the latter. In the SAURIAL and CHELONIAD, also, the third, which is translucent, moves from before backwards by means of a single muscle, and may cover the whole eye. In the lizard *genus* the eyelids consist of a circular veil drawn before the orbit, and perforated by a horizontal fissure, which is shut by a *sphincter*, and opened by a *levator* and *depressor*. The gecko has no movable eyelid.

Compound eye of the ARTICULATA.

In insects, the eye consists of innumerable hexagonal surfaces, slightly convex, and mutually separated by minute furrows, containing fine hairs variable in length. Each of these hexagonal surfaces, which constitute a hard, elastic, very transparent membrane, may be regarded as a cornea or crystalline lens, convex externally, concave within, and thicker in the centre than on the margins. Immediately behind is an opaque, viscid coating, varying in colour in the different species, analogous to the choroid pigment of the vertebrated animals, and completely obstructing the transmission of light. Beneath this varnish are short, whitish filaments, corresponding in number to the corneal surfaces, and mutually joined like mosaic or tessellated pavement, separated only by the dark-coloured pigment, and which appear to correspond to the *retina* of the VERTEBRATA. Behind these again is a delicate, dark-coloured membrane, which appears to correspond to the choroid; and exterior to this is a membrane continuous with the optic nerve, and which seems to be a *general retina*, forming, by subdivision of its parts on the anterior part of the choroid, the *divided* or multiplied *retina*. This is the structure of what are named *compound eyes*. That of the simple eyes of insects is too minute to be accurately demonstrated; but analogy gives probability to the inference that they are not dissimilar.

SECT. III.—THE EAR.

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In warm-blooded animals generally, that is, in the MAMMALIA and BIRDS, the labyrinth or essential part of the organ consists of three semicircular canals, with a globular enlargement to each (*ampulla*), a cavity common to these canals named vestibule (*vestibulum*), and a conical tapering canal, divided into two compartments by a longitudinal *septum*. This may be named the bilocular cone (*conus bilocularis*). These parts consist of membranous substance inclosed in the bony walls of the pyramidal or auditory bone. In all the MAMMALIA the bilocular conical canal is convoluted in a spiral form, and hence is denominated, as in man, the *cochlea*—a name, however, which is applicable to it in this class only.

Cochlea and canals.

The organ of hearing in the MAMMALIA consists of the same parts nearly as in man. In some, indeed, for instance the guinea-pig (*cabiai*), and porcupine, the *cochlea* makes three turns and a half; and, conversely, in the CETACEA only one and a half. In most of the ZOOPHAGA, and in the hog, elephant, and horse, the *cochlea* is much larger in proportion than the semicircular canals; but in the hare it is small, and in the mole very small. In the CETACEA, while the *cochlea* is very large and fully developed, its spiral is on the same plane throughout; and the semicircular canals are so small, that their existence was long denied by Camper, till they were demonstrated by Cuvier in a fœtal whale. In general the labyrinth of the MAMMALIA is greatly smaller in proportion to the head than in BIRDS.

This part, which is membranous, is inclosed in the solid compact substance of the temporal pyramid, so closely that its existence appears to be identified with the latter. Researches, however, on the labyrinth in the fœtus of the MAMMALIA, and especially in those of whales, demonstrate the fact that it is in a completely membranous form, distinct from the bony inclosure; that in shape and constituent parts it exists previous to the bony inclosure; and that the latter is afterwards moulded round the different parts as they acquire their full developement. It is also to be observed, that in the mole the semicircular canals are seen within the cranium without preparation, and the *cochlea* is merely inclosed in fine cellular tissue. In the bat family, also, both parts are seen without bony inclosure.

Tympanum.

The tympanum forms a cylindrical or spheroidal cavity in most of the MAMMALIA. In most of the DIGITATA the mastoid process consists of a slight prominence of the *tympanum* only as it is identified with the latter; but in the *cabiai*, guinea-pig, hog, the Ruminants, and SOLIDUNGULA, it is represented by a long process of the occipital bone. In most of the ZOOPHAGA and RODENTIA the *parietes* of this protuberance, which are thin and hard, form by their separation a large cavity. In the hog only it is occupied by a firm cancellated structure.

Tympanal bones.

All the MAMMALIA, except the *ornithorhyncus*, have the tympanal bones as in man; the hammer (*malleus*), anvil (*incus*), orbicular bone and stirrup (*stapes*). The lenticular bone, which is rarely found in the adult, is probably only an epiphysis of the anvil. They are articulated with each other so as to admit of motion, and are moved by the same muscles as in the human subject—the *internus mallei*, *externus mallei*, *laxator tympani*, and *stapedius*. In the *ornithorhyncus*, however, there are only two tympanal bones.

External aperture.

In all the MAMMALIA, except the Cetaceous, the ear is provided with a bony external canal (*meatus*); and most of the MAMMALIA, except the Cetaceous, have a cartilaginous funnel-shaped opening (*concha*) attached to the outer margin of the bony *meatus*, and which serves to

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collect the sonorous vibrations, and direct them to the *meatus*. The other exceptions are among the INSECTIVORA, the mole, and some of the shrew *genus;* among the RODENTIA, the *zemni* or blind rat, and some of the rat-mole *genus;* among the EDENTATA, the pangolin or scaly ant-eater; and among the AMPHIBIA, the morse and several species of seal; and the *ornithorhyncus paradoxus.*

The *tympanum* of the CETACEA is peculiar. It consists of a bony plate, convoluted on itself like a *buccinum*, unless that the thick side, instead of containing a spiral cavity, is entirely solid. The opposite side is thin, with an irregular margin. The anterior extremity of the *tympanum* is open, and there commences the Eustachian tube, which ascends along the pterygoid process, and, penetrating the maxillary bone, terminates at the upper part of the nose. This direction of the tube and position of its orifice is so much more necessary, because, since these animals have no external bony *meatus*, and the ear-hole scarcely admits a pin, the vibrations of the air reach their organ of hearing entirely by the Eustachian tube, and because the Eustachian tube also in these animals conveys odorous impressions to the part in which the sense of smell appears to reside. The aperture by which it communicates with the nose is provided with a membranous valve, which prevents the water from entering when the animal expels it by his nostrils.

In BIRDS, of the three semicircular canals the vertical is largest, and obliquely directed forwards and outwards; the second is horizontal and turned outwards; and the third, which, like the first, is vertical, crosses the second, and is turned in the direction opposite to that of the first. The vestibule is small and nearly spherical. The bilocular cone, which is obtuse at the *apex*, is situate obliquely backwards and outwards below the inferior part of the cranium. The longitudinal septum consists of two narrow cartilaginous plates connected by a thin membrane. The posterior canal is short, and, as in the MAMMALIA, is separated from the tympanal cavity by the membrane of the *fenestra rotunda;* while the anterior, which is larger, communicates directly with the vestibule. The whole of these parts are inclosed, as in the MAMMALIA, in the compact bone of the pyramid.

Bilocular cone no longer spiral.

The posterior and inferior walls of the tympanal cavity are formed by part of the occipital bone; the lateral aperture is large, and the cavity superficial; and its anterior part is closed by the posterior superior *cornu* of the quadrilateral bone and a membrane. The inner wall presents the two apertures—the oval or vestibular, and the round or cochlear. In this class, however, while the upper is round or triangular, the lower is distinctly elliptical,—a disposition the reverse of what is observed in man. The Eustachian tube or tympano-guttural canal is entirely osseous. The tympanal cavity contains only one *ossiculum*, consisting of two branches; the first attached to the tympanum, corresponding to the *malleus;* the second closing by an oval or triangular plate the vestibular aperture, and therefore corresponding to the *stapes* of the MAMMALIA. By Carus the incus is supposed to be represented by the quadrilateral bone.

Tympanal bones disappearing or modified.

The external *meatus* is short, and opened by a simple aperture, while the absence of external ear is compensated by a ring or zone of fine elastic feathers with thin barbs, between which the air passes very easily. In the owl tribe it terminates in a large cavity, the margins of which are covered by a smooth valvular fold of skin.

Bilocular cone disappears.

The ear of the REPTILES is remarkable for the last appearance of the bilocular cone, and the first of the saccular apparatus which is found in the Fishes. In the crocodile and lizard this part appears, as in Birds, in the shape of a conical tube, divided by a cartilaginous partition into a double canal, one separated by the membrane of the round hole from the tympanal cavity, the other communicating with a membranous sac containing three very small friable stones, not harder than starch. There are also three semicircular canals of considerable size, each forming a large circumference. In the frog and toad, while the three canals form almost a complete circle, the sac contains an amylaceous friable stone; but the bilocular cone is no longer observed. In the salamander, also, in which the three canals form together a sort of equilateral triangle, the sac which is below contains a single amylaceous stone. The same arrangement is observed in the Cartilaginous Fishes, unless that the sac contains two amylaceous stones, nearly oval in shape, suspended in a gelatinous semifluid pulp. In the Osseous Fishes it is a little different. The three semicircular canals terminate in a membranous sac, which is divided by septa into compartments which contain one, two, or three small stones suspended in gelatinous fluid. These minute stones, however, instead of being soft, friable, and amylaceous, as in Reptiles and cartilaginous Fishes, are as hard as rock, and white as porcelain. These parts are situate on the sides of the cranial cavity, and are fixed to it by cellular tissue, vessels, and osseous or cartilaginous processes. This sac, in the fluid of which the extremities of the auditory nerve are distributed, is believed to correspond to the bilocular cone of the higher classes.

Lithophorous sacs and amylaceous stones appear.

These membranous cavities are contained, in the bony fishes, in the general cavity of the cranium; and while only the middle of the canals is inclosed in the bone of the cranium, the extremities and the sac are quite free. The sturgeon, which belongs to the cartilaginous order, is the first in which the canals are entirely inclosed in the cranial cartilage; but even in this a membrane is interposed between the cranium and sac, which is free. In the ray and shark *genera*, again, these organs are entirely inclosed in the cartilage of the head.

The tympanal cavity, in like manner, is modified, and eventually disappears as we descend in the scale. Though present in the tortoise, crocodile, and lizard tribe, it is superficial and open; it becomes membranous behind in the RANINE tribe, and communicates directly with the back of the mouth; and in the SERPENTINE reptiles it entirely disappears, so that the handle of the osseous plate by which the oval aperture is closed is suspended in the soft parts with its free extremity below the skin, near the articulation of the lower jaw. In the lizard tribe, also, the round or cochlear aperture is seen for the last time. In the Cheloniad, for instance, the Batrachoid, and the Serpentine, this aperture disappears, and the oval or vestibular alone is left; and in the salamander both disappear, and there is no communication between the external part of the cranium and the labyrinth. This arrangement is continued in the fishes.

Cochlear aperture disappears.

Vestibular aperture disappears.

In the molluscous animals the labyrinthine membrane is a simple sac, globular or ovoidal, containing pulpy matter, in which is suspended a small body, which is osseous in the *sepia* and amylaceous in the many-feet (*polypus*), in which the filaments of the auditory nerve are distributed.

Our limits do not allow us to enter into the detailed description of the organ in the other INVERTEBRATED animals.

SECT. IV.—THE ORGAN OF TASTE.

Though the sense of taste is seated chiefly in the tongue in animals, yet that organ performs, in all the classes, so important a part as an instrument of prehension, that it cannot with much justice be distinguished by the former title only. In the present section, therefore, we must regard it as one of prehension as well as of taste.

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The tongue.

In the MAMMALIA and BIRDS the tongue is a muscular organ invested by mucous papillated membrane, supported by a proper bone, the hyoid, which serves as a point of support in its various motions. In the RANINE REPTILES it is also muscular, attached to the margin of the lower jaw. In the salamander, however, it is attached as far as the tip, and is movable on the sides only. In the crocodile it is attached so generally, both by tip and margins, that it was long asserted that the animal was tongueless. In the *stellio* and *iguana* it is as movable as in the MAMMALIA; and in the scinc and gecko to this property is added that of being bifid, or divided by a longitudinal notch into two pointed tips. In the ordinary lizard, tupinambis, monitor, &c. the tongue is remarkable for its great extensibility, and terminates in two long, flexible though semi-cartilaginous extremities. That of the chameleon is still more extensible, and forms, by a peculiar arrangement of vessels, a cup-like extremity. The tongue of the blind worm (*anguis fragilis*) and *amphisbæna* is also bifid at the tip. The cartilaginous fishes are void of tongue, while in the bony division of the class this organ is represented by a hard protuberance, attached to the middle branchial bone.

Erectile arrangement in the tongue of the giraffe,

In some of the MAMMALIA, however, the tongue is not exclusively muscular. In the singularly long, extensible, and tortuous tongue of the giraffe, Sir Everard Home describes a peculiar arrangement of vessels, which he represents as a substitute for muscular motion. Though Sir Everard does not appear to understand the exact nature of this arrangement of vessels, all the circumstances tend to show that it is that denominated erectile. These vessels, from the account given, are large, numerous, and communicate freely; and it would be impossible to discover the reason of such a vascular system, unless for some purpose of this description. (*Phil. Trans.* Comp. Anat.) When the tongue is protruded it becomes perfectly black or bluish-black, evidently from the injection and detention of the blood in its elongated and anastomosing veins. By means of this mechanism the giraffe not only elongates the tongue to the distance of about twenty inches or two feet beyond the mouth, but twists it round the soft leafy twigs of the trees on which he feeds. It is not improbable that a similar vascular arrangement exists, though in less degree, in the tongue of the deer, and in the long projectile tongue of the animals of the ant-eater tribe, as the *Tamanoir*, *Tamandua*, &c.

And of the chameleon.

The erectile arrangement is still more distinctly presented in the tongue of the chameleon. The researches of Mr Houston of Dublin show that the tongue of this animal consists of two parts,—a prehensile, which is anterior, and provided with a glandular apparatus for secreting the viscid fluid by which its tip is covered, and insects are entangled; and an erectile, which is posterior between the prehensile and the hyoid bone, in the form of a trellis-work of innumerable minute anastomosing blood-vessels, not very dissimilar to those of the cavernous body in animals generally, and inclosing a central tube connecting the prehensile portion to the hyoid bone. The effect of this arrangement is, that when the vascular network is injected with blood, the anterior part of the tongue is rapidly darted out at the insects on which the animal lives. The injection of these vessels, and the consequent projection of the tongue, is not independent altogether of the will of the animal; for the veins by which the blood is returned pass through a slit in the tendon of the internal cerato-maxillary muscles, which are always contracted in order to protrude the hyoid style, and thereby tend, by compressing the veins, to inject the erectile part, and project the tongue. (*Trans. R. I. Acad.* 1828, and *Dublin Hospital Reports*, vol. v. p. 487.) The same arrangement is in all probability found in several of the lizards, the tongues of which, like that of the chameleon, are darted out suddenly, and become of a dark-blue colour at the moment of projection.

Papillæ.

In all the MAMMALIA the tongue is invested by a papillated muco-villous membrane, in which the papillæ are of the same general characters as in man—granular, mushroom-like, or fungiform, tubercular or calycoid, and conical or acuminated. The only differences consist in the size and abundance of the fungiform *papillæ*, in the number of the calycoid and the mode of their arrangement, and in the shape of the conical papillæ and the mode of their termination. In the Ruminants especially, the conical papillæ are numerous, long, slightly incurvated, and each terminating in a horny but flexible style slightly incurvated backwards. The tongue of the dolphin and porpoise, examined even by the microscope, presents no distinct conical papillæ, but is covered by minute eminences, each penetrated by a small aperture.

Worm of the dog; its absurdity.

In the tongue of the dog *genus* there is a ligamentous substance extended longitudinally from the hyoid bone to the tip of the member. This, which has been vulgarly distinguished by the name of *worm* of the tongue, and has been absurdly supposed to be the seat of hydrophobic *rabies*, is merely a central pillar of support for the muscular fibres to act with greater steadiness and effect, and which enables the animal to protrude and expand the tongue in lapping water or other fluids better than he could have otherwise done. A similar central ligament is found in the opossum.

The tongue of BIRDS is generally more or less horny, and almost cartilaginous. That of the woodpecker and wryneck is peculiar in consisting of two parts,—a basilar or posterior, loose and fleshy; and an anterior projectile, long, smooth, acuminated, and covered laterally with four or five stiff spines directed backwards, which make the organ a sort of barbed arrow. The soft, loose, or basilar part of the tongue contains the aperture of the glottis; and the surface is covered with minute spines pointed backwards, and each of which is placed in the centre of a fleshy *papilla*.

Trunk of the elephant.

As a prehensile organ of very singular construction, the trunk of the elephant deserves particular notice; and it cannot be more conveniently introduced than under the present section, since it is used not only to convey food, but drink, into the mouth. The trunk may be described as a cylindrical tubular organ, consisting of integument, a sort of fibro-cartilage, muscles, fat, and a membrane of villous character internally. This tube contains two long canals continued from the nostrils, parallel to the axis of the trunk, and separated throughout by a partition of adipose substance about two fifths of an inch thick. From the extremity to the middle part of the intermaxillary bone, in which the tusks are fixed, these canals are nearer the anterior-superior than the posterior-inferior part of the tube, the latter wall being thickest; and their diameter is the same throughout. At this part they undergo a sudden incurvation, approaching the anterior surface of the intermaxillary bone, and form a semicircular bend with the convexity turned forwards. Here also they are so narrow that, without a muscular effort on the part of the animal to dilate them, fluids could not ascend beyond this point; and hence this forms the only valvular contrivance, either to impede the progress of fluids upwards, or to propel them downwards, at the will of the animal.

Above this curvature each canal is dilated before the upper part of the intermaxillary bone, and again is contracted where it bends back to enter the bony nostril; and the curvature is protected before by the nasal cartilage, which is oval, convex in the male, and flat in the female.

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Muscular apparatus of the trunk highly complicated.

Both canals are lined by a dry, greenish-yellow coloured membrane, marked with superficial intersections (*rugæ*), inclosing rhomboidal spaces, and some venous branches.

Though the muscular *fasciculi* of the trunk are numerous, they may be referred to two orders,—those forming the substance or inner part of the organ, and those by which it is invested. The former, which are transverse, and cut the *axis* in different directions, consist of numerous small muscular packets proceeding in various directions, some running from the inner membrane to the circumference of the tube, others directly from right to left, and others crossing the two former obliquely. All these little muscles are inclosed in cellular tissue, containing white homogeneous fat; and all of them terminate in slender tendons, some of which cross the layers of the longitudinal muscles in their course to the external covering, while others are attached to the internal membrane. Cuvier calculates the number of these minute transverse muscles in the trunk of the elephant to be not fewer than 30,000 or 40,000. (Plate XXXVII. fig. 13.)

The longitudinal muscles, which are external, may be distinguished into anterior, posterior, and lateral bundles. The first extend from the anterior surface of the frontal bone, above the nasal bones and cartilages, in parallel bundles, connected by tendinous intersections downwards on the trunk. The posterior extend from the posterior surface and inferior margin of the intermaxillary bones, and form two layers which meet on the median line along the lower surface of the trunk. The lateral muscles form two pairs, one of which, descending between the anterior and posterior muscles to the middle of the trunk, may be regarded as a continuation of the orbicular muscle of the lips, or the representative of the *nasalis labii superioris;* while the other, which is attached to the anterior margin of the orbit, and is expanded over the root of the former, may be supposed to correspond to the *levator* of the upper lip.

The whole of these muscles are supplied by a very large branch of the infraorbital or second branch of the trifacial nerve, which, entering on each side between the lateral and superior muscle, is distributed to the whole of the trunk.

With such a construction, it is not difficult to understand the numerous motions of the elephant's trunk. While the longitudinal muscles are employed either to shorten the tube, to bend it upwards or downwards or to the side, or by means of the tendinous intersections to give it peculiar inflections, it is manifest that the transverse ones, which act as antagonists to the longitudinal, may also either dilate or close the canals, or incurvate or alter the direction of particular parts.

Vacuefying apparatus in the feet of certain animals.

The foot of the *Lacerta Gecko* and the house-fly presents a prehensile apparatus of peculiar construction for walking along surfaces, in opposition to the action of gravity. In the former animal the plantar surface of each toe presents sixteen transverse slits, leading into an equal number of pouches, which by means of appropriate muscles are capable of forming an equal number of *vacua*, so that the atmospheric pressure is employed with muscular effort to support the animal in his unnatural position. A similar apparatus is found in the upper surface of the head of the sucking fish (*echeneis remora*); and something approaching to it, though less distinctly, in the foot of the walrus. (Home, *Phil. Trans.* 1816.)

CHAP. IV.—COMPARATIVE ANATOMY OF THE ORGANS OF VOICE.

Under this head our limits allow us to mention very few circumstances.

In the American long-tailed monkeys (*sapajous*) the cuneiform cartilages form, by means of adipose cellular tissue, before the upper extremity of the ventricle of the *glottis*, a large cushion like a spherical segment, which, touching that of the opposite side, causes the air to whistle through the canal in its course to the mouth, and occasions the flute-like voice of some of these animals, as the weeper (*s. apella*) and the capuchin (*s. capucina*). In the howler (*s. seniculus*), so remarkable for its morning and evening yelling, though the larynx is similar in general characters to that of the common *sapajou*, in having the two rounded cushions before the ventricles, the hyoid bone is arched in the form of a spherical chamber, with a large quadrilateral aperture, and each ventricle opens into a membranous sac, lying between the *epiglottis* and the adjoining wing of the thyroid cartilage. The air, which passes between the vocal chords, is therefore partly impelled into this osseous and elastic cavity of the hyoid bone, and probably by its resonance in this situation gives the voice of these animals the deep-toned howl by which they are known in the American forests.

Voice of the howler ape,

Among the ZOOPHAGA, in the dog the cuneiform cartilages are large, the arytenoid small, the vocal chords well marked, and the ventricles deep. In the feline tribe the anterior ligaments, though destitute of cuneiform cartilages, are thick, and separated from the back of the epiglottis by a broad, deep furrow. The posterior ligaments, though neither free nor sharp-edged, are distinguished from the anterior by an appearance of greater firmness, more regular fibres, and by an intermediate furrow. The approximation of the anterior ligaments towards the *glottis* forms a sonorous vault, in which the air may be forcibly vibrated by the posterior. In the bear the cuneiform cartilages assume the shape of styles, and their posterior extremity forms a distinct eminence, not above, but without the arytenoid cartilages, while the ventricles are merely deep fissures.

The kangaroo has neither cuneiform cartilage, anterior ligament, nor ventricle; and it may even be said to be void of vocal chord, while the margins of the *glottis* are much separated in the middle. This arrangement appears to indicate that the animal is almost destitute of voice. In the opossum, in which there is merely a small inferior ligament susceptible of tension, voice is limited to a whistling sound.

In the SOLIDUNGULA, in which the cuneiform cartilages are completely concealed by the mucous membrane, there is neither superior ligament nor proper ventricle; but an aperture in the lateral wall of the laryngeal membrane, above the vocal chord, leads into a large, oblong, sinuous cavity, situate between this membrane and the thyroid cartilage, and covered chiefly by the thyro-arytenoid muscles, by which it may be compressed; and above the anterior commissure of the vocal chords, or below the base of the *epiglottis*, is an aperture on the mesial plane, leading into a cavity below the vault formed by the anterior margin of the thyroid cartilage. This cavity, which may be named the infrathyroid, is superficial in the horse, and its aperture is large; while in the ass, with a small, round aperture, the cavity is large, capacious, and globular in every direction, and allows the latter animal to make his voice re-echo in the singularly harsh sound denominated the *bray*. Conversely, though the lateral cavities are equally large in both animals, the apertures in those of the ass are small, round, and situate nearer the *epiglottis* than the vocal chord, while those of the horse are large, oblong, and situate immediately above the vocal chord on each side. On the latter peculiarity appears to depend the neigh of the horse.

of the ass, and horse.

In the CETACEA we recognise neither vocal chords nor *glottis*, that is to say, an aperture variable in size ac-

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cording to the will of the animal; but the superior part of the *trachea*, which represents the larynx, forms a hollow pyramid or funnel, rising into the posterior part of the nostrils, in which only it opens, while on the sides is left a passage for the food. This pyramidal funnel is formed by an elongated triangular cartilage, corresponding to the *epiglottis*, attached by membrane to the arytenoid cartilages, which also take the shape of scalene triangles, with the small side connected to the cricoid cartilage. Strictly speaking, therefore, the CETACEA have no larynx, and probably no vocal organ; and the superior part of the *trachea*, with the nostrils, serves merely to admit the atmospheric air for the purposes of respiration.

BIRDS are distinguished by possessing not only a *glottis* or laryngeal aperture similar to that of the MAMMALIA at the upper end of the *trachea*, but a second, denominated the inferior *glottis* or *larynx*, at the lower end, near its bifurcation. The former, which is composed of four cartilages, or six, according as the cricoid consists of one or three pieces, on the middle of the posterior part of which is a small round bone, articulated with two oblong longitudinal bones, parallel, and forming between them in the posterior wall of the windpipe a longitudinal slit, susceptible of approximation by means of muscles, is intended merely to regulate the admission of air into the windpipe, or its expulsion from that tube, and to close more or less accurately its superior orifice.

Inferior or modulating larynx of birds.

The inferior larynx consists of a membrane projecting from each side of the inferior aperture of the *trachea*. This aperture is divided into two, occasionally by an osseous anterior-posterior middle bar, occasionally by the angle at which the two bronchial tubes unite. Since the first bronchial arc has the same curvature as the last tracheal ring, the second and third, which are arcs of larger circles, are less convex without, but more prominent within, than the former. Over this prominence the tracheo-bronchial membrane forms a fold, which, half closing on each side the inferior tracheal aperture, forms a plate susceptible of vibrating by the motion of the air, and producing sound. This apparatus, which constitutes what is named the *inferior larynx*, or rather *glottis*, is of two kinds, one void of proper muscles, the other provided with muscles.

In the former kind of larynx the state of the glottis is altered only by those muscles which depress and elevate the trachea. The depressors are two pairs, the sterno-tracheal and the glosso-tracheal, the latter attached to the bifurcated bone and *trachea*. There are no proper elevators; but the windpipe is raised by the mylo-hyoid muscle through the ligaments which connect the hyoid bone to the superior larynx. In the quiescent or relaxed state, and while the trachea is depressed, the bronchial rings approximate, and the second and third even gliding below the first, the *glottis* may be elongated. When the trachea is elevated by these pairs of muscles, the *bronchi* are at the same time dragged upwards, and the second and third arcs are separated from the first; and while the external prominence of the glottidal membrane diminishes in length, its tension is augmented. These forms of larynx without proper muscles may yet be subdivided into two sorts, as they have or have not lateral pouches, membranous or osseous. These are observed in the male duck (*anas*) and the merganser (*mergus*), but never in the female; and to this perhaps the harsh and deep tone of the voice of the male bird is to be ascribed. The larynx without muscles and without pouch is observed in all the gallinaceous order without exception.

The forms of larynx provided with proper muscles may be distinguished into three subdivisions.

The first, which has only one proper muscle on each side, is observed in the whole of the falcon *genus*, e. g. the eagle, hawk, falcon, buzzard, sparrow-hawk, and goss-hawk; in the owl *genus* and the majority of the waders and swimmers, as the heron, bustard, woodcock, lapwing, rail, coot, gull, cormorant, and some of the passerine birds. In these birds, in which the motions of the lower larynx are necessarily limited, the voice is not variable or extensive in its notes.

The second form of *larynx* has three pair of proper muscles, a *constrictor* of the *glottis*, an auxiliary constrictor, and a *laxator* or opener of the glottis. This kind of larynx is observed in the whole of the parrot *genus* and psittacoid birds generally, as the toucan, macaw, calao, &c.

In the third kind of musculo-membranous *larynx* there are no fewer than five pair of muscles, the longitudinal *levator* of the demiannular cartilages, the posterior *levator* of the same cartilages, the small *levator*, the oblique *levator*, and the transverse *levator*. This quinque-muscular larynx is found not only in all the birds properly named whistlers or warblers, as the nightingale, hedge-sparrow, blackbird, thrush, goldfinch, lark, linnet, canary, chaffinch, &c., but in others whose tones are more monotonous, as the swallow, sparrow, stork, crossbill, &c., and even in some the tones of which are harsh and positively disagreeable, *e. g.* the jay, magpie, crow, raven, &c.

The differences remarked in the notes of these three divisions of birds with the quinque-muscular larynx depend not so much on anatomical peculiarities as on the *timbre* of their larynx, and on the mobility of the *trachea* in relation to the larynx, and on the tracheal membrane having dilatations and contractions.

On the whole, the inferior larynx of birds is to be regarded in three lights: 1*st*, As the reed of a wind-instrument, like a hautboy or clarionet, in which the notes vary as the lower glottis varies in its position to the windpipe; 2*d*, as an instrument susceptible of uttering different tones, according to the distance between the mouth-piece and vent, or as the windpipe is elongated or shortened; and, 3*d*, as an instrument capable of uttering different notes by varying the diameter of the mouth-piece, or as the superior *glottis* is widened or contracted.

The only bird in which the inferior larynx is wanting is the vulture.

The vocal organ of the REPTILES consists of the superior larynx only, analogous to that of the MAMMALIA. This is a cartilaginous apparatus, composed in general of five distinct pieces at least in the large individuals of the SAURIAL *genera*, as the crocodile and alligator, and forming a broad cavity behind, before a narrow slit, bounded by two vertical pillars. The *glottis*, however, is entirely membranous; and there are neither vocal chords nor ventricles. There are nevertheless two muscles, one for opening and another for shutting the *glottis*. When these act, and the air is made to vibrate against the anterior pillars, it gives a slight whistling sound only. In the iguana, tupinambis, lizard, tortoise, and serpent, the arrangement of parts is nearly the same; and these animals, therefore, can utter only slight hissing sounds. In the chameleon the pillars are furnished with a tense, vibrating membrane, a fleshy tubercle which contracts the *glottis*, and a membranous pouch opening below, between the lower laryngeal cartilage and the first tracheal ring. In the frog tribe, so remarkable for their croaking noise, the vocal chords are large and prominent. The males have also two membranous pouches, opening by a small aperture, not in the larynx, but deep in the lateral part of the mouth. When the frog croaks these pouches are inflated, and swell the skin on each side below the ear. Though these sacs are wanting in the female frog, and toad both male and female, as well as the tree-frog, there is beneath the throat a single pouch on the median plane.

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CHAP. V.—COMPARATIVE NEUROLOGY.

A general view of the nervous systems in different classes of animals shows that the only common part is an azygous tubercle, situate at the anterior extremity of the spinal chord, connected by means of two lateral bundles or peduncles to the rest of the system. This mass, which corresponds to what is denominated the *cerebellum* in man, is connected in the vertebrated red-blooded animals with several pairs of tubercles, forming generally a larger mass than itself, and connected to the rest of the system by two longitudinal bundles or limbs, which mingle with and intersect those of the cerebellum. These anterior-superior tubercles, which constitute the brain proper, present numerous modifications in figure, disposition, and magnitude, and even in presence, in the different orders of the animal world.

In the vertebrated animals the brain or central part of the nervous system consists of the vertebral or funicular portion, named the *spinal chord*, and the cranial or cephalic portion, properly denominated the brain.

Spinal chord.

The funicular portion has the shape of a *cylinder* flattened on its superior or dorsal and inferior or sternal surfaces. It consists of two similar chordiform productions, united on the mesial plane, and marked at the line of junction by linear longitudinal furrows, of which the superior is most deep and distinct. This, however, which was observed by Blasius in several animals, is denied by Bellingeri, who asserts, from various observations, that though in some parts the superior furrow penetrates more deeply than the inferior, in the general course of the chord the latter is the deepest. (*De Medulla Spinali Annotationes Anatomico-Physiologicæ.* Auctore C. F. Bellingeri, Aug. Taurinorum, 1823.) This discordance appears to depend on the circumstance that the sternal or inferior furrow is in truth deeper and more distinct in man, the monkey tribe, and a few MAMMALIA, than the dorsal; whereas in most others, as the coati, raccoon, horse, &c. the dorsal furrow is of the same depth as the sternal; and in the mole, murine, and leporine *genera*, it is deeper and more distinct than the sternal. In BIRDS and the cartilaginous FISHES the sternal furrow is deepest; in Reptiles the dorsal and sternal are nearly equally deep; and in the osseous FISHES the dorsal is the deepest. On each side of the chord, also, there is a slight longitudinal depression commonly called the lateral (*sulcus lateralis*).

The breadth and thickness of the spinal chord vary in different regions. The lower cervical portion is in general the broadest and thickest; at the upper dorsal region it is somewhat more slender, becoming thicker again at the lower dorsal region; and after again becoming more slender in the lumbar region, it is expanded into a filamentous brush-like termination of different lengths in different classes, and even in different orders. These enlargements at the superior dorsal and lumbar regions are believed by Serres to correspond with the origins of the thoracic and pelvic extremities; and each swelling he represents to predominate over the other, as the animal habitually employs the one or the other kind of members. It is remarkable in illustration of this principle, that in the CETACEA, which are void of pelvic extremities, the lumbar enlargement is wanting; and in the amphibious MAMMALIA, the pelvic extremities of which are feeble, this enlargement is also inconsiderable.

The spinal or funicular brain consists of white cerebral matter on the surface and gray matter in the centre, the former being most abundant, unless in the sacral region, where both are nearly equal in quantity, or the gray rather predominates. In the MAMMALIA the gray matter is in greater proportion to the white than in the other three classes, in which the white matter progressively augments.

The sternal and dorsal longitudinal lines indicate the original formation of the chord in two lateral portions, with an intermediate cavity denominated the spinal canal. This exists only during the formation of the chord in the human fœtus, in some of the MAMMALIA when adult, and in the other three classes. Its disappearance in the human fœtus, and in that of various MAMMALIA, is represented by Serres to depend on the progressive deposition of gray cerebral matter on the inner or central surfaces of the component pillars of the chord. Though obliterated in man, in whom the gray matter is abundant, it is not hermetically sealed in the monkey tribe, in which some traces of it are left. In the AMPHIBIA and CETACEA it is larger than in the monkey tribe; its diameter augments in the CARNIVORA, feline, canine, and ursine, in which the gray matter is thinner than in the former; and in the RODENTIA it is said to be largest of all among the MAMMALIA. Lastly, in the birds, reptiles, and fishes generally, in which the gray matter is scanty and the white predominates, the spinal canal is large and distinct.

The lateral regions of the spinal chord are connected with a double series of nerves by means of two rows of nervous filaments, an anterior and posterior, separated by a longitudinal membrane of fine white tissue, with a serrated or festooned border. This membrane, which is named the denticulate, is the same in the MAMMALIA and BIRDS. That these nerves do not issue from the spinal chord, must be inferred not only from the phenomena attending the original developement of the nervous system, but especially from what is observed of their comparative size, and that of the chord in the inferior classes. In that of fishes especially, while the chord is small and slender, and by no means fills the vertebral canal, it is remarkable that the nerves which supply the voluntary muscles are exceedingly large. Thus, in many both of the cartilaginous and osseous divisions, as the sturgeon, dog-fish, ray, wolf-fish, cod, &c. the nerves which supply the pectoral fins are large, broad chords, two or three of which seem to contain more substance than the whole spinal chord itself.

Bulb of the chord.

The chord is expanded at its cephalic end into a thick eminence denominated the spinal bulb, the surface of which presents three pairs of eminences. These eminences are developed in various degrees in the different classes and orders. In some of the MAMMALIA the anterior pyramids or pyramidal bodies are more distinct than in man, for instance the ape tribe, the CETACEA, CARNIVORA, Ruminants, and RODENTIA. They are small in most Birds, all the Reptiles, and the Cartilaginous FISHES. In the osseous division they assume the appearance of two parallel chords at the base of the brain. The olivary bodies, less prominent in the ape than in man, are still less so in the CETACEA, and progressively through the AMPHIBIA, CARNIVORA, RUMINANTIA, RODENTIA, and INSECTIVORA, and the other three great classes of vertebrated animals. Conversely, the restiform bodies or posterior pyramidal eminences, from man through the ape tribe, the CETACEA, AMPHIBIA, to the Ruminants, CARNIVORA, and RODENTIA, increase in size.

Though the brain of the MAMMALIA presents the same parts, and is arranged nearly in the same order, as that of man, it varies in its proportions to the rest of the body; in its proportions to the *cerebellum* and spinal bulb; in general figure; in the presence, absence, and number of convolutions; in the configuration of its central surface; in the communication of its central with its external surface; and in the manner of its connections with the cerebral nerves. As it is impossible in this sketch to examine all

these circumstances fully, we shall confine our attention to the notice of a few only.

It is not easy to ascertain the proportion of the mass of the brain to that of the rest of the body. Excluding as much as possible the ordinary sources of fallacy, in small animals the brain is proportionally larger; yet in this respect man is surpassed only by a small number of animals, habitually lean, and with little muscle, as bats, small birds, &c. While the proportion of brain in man to that of the whole person varies from a 22d to a 35th part, that of the monkey tribe varies from a 22d to a 42d part; and in the baboon it is only the 104th part of the body. Among the MAMMALIA, the RODENTIA have in general the largest proportion of brain, and the PACHYDERMATA the smallest; and while the hare has a brain about the 300th part of the size of the body, that of the elephant, the most sagacious of animals, is about the 500th part the size of his body. It is also remarkable, that while the brain of the horse is only a 400th part of the size of his body, that of the ass amounts to a 254th part. The Reptile brain becomes excessively small, that of the turtle being rather more than the 5000th part the size of his body; and in some of the Fishes, not all, it appears to attain the maximum of decreasing proportion, that of the tunny being so small as the 37,000th part of his body, while the brain of the carp is so large as to approach the proportion of the elephant. It may be doubted whether, under such circumstances, any precise conclusions can be drawn from results so variable and so little to be expected.

The proportional weight of the brain to that of the *cerebellum* is, excepting in the case of one species of ape, the *saimiri*, greater in man than in any other animal. The ox is equal to man in this respect, and the dog approaches him. The animals most remote are the RODENTIA, as the beaver, rat, and mouse, &c.

The convolutions, which are so numerous and so deep in man, diminish both in number and size in the QUADRUMANA and CARNIVORA, and are nearly obliterated in the RODENTIA. In the UNGULATED animals, however, and especially in the Ruminants and the horse, the convolutions are numerous; and even in the dolphin among the CETACEA, they are numerous and deep. In all the MAMMALIA the *cerebellum* is foliated.

On the whole, the peculiar character of the brain of man and the ape family consists in the existence of the posterior lobe and digital cavity. The brain of the ZOOPHAGA is remarkable for the small size of the *nates* or anterior pair of the bigeminous eminences in proportion to the *testes* or posterior pair. In the RODENTIA the organ is distinguished for the large size of the *nates*, and the want or superficial nature of the convolutions. In the UNGULATED division of animals, *i. e.* PACHYDERMATA, RUMINANTIA, and SOLIDUNGULA, the brain is remarkable for the large size of the *nates* combined with the number and depth of the convolutions; while that of the CETACEA is remarkable for its height and breadth, and the want of olfactory nerves. It is further to be observed as a general distinction between herbivorous and carnivorous or zoophagous animals, that in the former the *nates* are larger than the *testes*, whereas in the latter the *testes* are largest. Lastly, Man and the QUADRUMANA are the only animals which possess genuine olfactory nerves. In the other quadrupeds they are represented by the mammillary processes of the ancients; and in the CETACEA they have not yet been unequivocally demonstrated.

The brain of BIRDS is at once recognised by consisting of six distinct tubercles, two representing the cerebral hemispheres, two representing the optic eminences, one the cerebellum, and one the bulb of the chord. The hemispheres are void of convolutions, but the cerebellum is marked by transverse parallel striæ corresponding to the *laminæ* of the mammiferous brain. There is neither middle band (*corpus callosum*), vault, nor *septum*. The ceiling or vault of the aqueduct or passage from the third to the fourth ventricle is not, as in the MAMMALIA, surmounted by the bigeminous eminences, but is merely a thin plate corresponding to the valve. Each optic eminence contains a cavity communicating with the others by the Sylvian aqueduct. The anterior eminences (*corpora striata*) are not striated with alternate white and gray matter, as in the MAMMALIA. Between the anterior and the optic eminences are four rounded tubercles, best seen in the ostrich, which are to be regarded as entirely heterologous to the structure of the mammiferous brain, and connecting the cerebral structure of BIRDS with that of Reptiles and Fishes, in which also these tubercles are observed.

The Reptile brain is smooth and unconvoluted. The optic eminences, which are situate behind the hemispheres, are uncovered, and contain a ventricle communicating with the third. At the extremities of the latter are the anterior and posterior commissures, but there is neither soft commissure nor bigeminous eminences. The hemisphere presents an anterior eminence, which, however, in the brain of Birds is unstriated. The cerebral valve is, like that of BIRDS, unsurmounted by bigeminous eminences.

In the class of FISHES the structure becomes still more simple. The tubercles of which the brain consists are placed in a row; and their increase in number only demonstrates the decomposition of the organ, and its resolution into simple integrant parts. The two representing the hemispheres are ovoidal, unconvoluted, and contain a ventricle, in which is seen the eminence analogous to the striated bodies. The optic eminences, situate beneath the hemispheres, though small, contain each a cavity, as in the two oviparous classes already noticed. Lastly, there are in several *genera*, under the common vault of the hemispheres, occasionally two, occasionally four tubercles, variable in shape and proportions, but which would be analogous to the bigeminous eminences, were they not, like those already mentioned in BIRDS, situate before and above the optic chambers. In the cartilaginous fishes, in which these tubercles are not observed, the anterior or striated eminences are obliterated. The *cerebellum* does not cover the fourth ventricle.

Behind the *cerebellum* are two tubercles, which in the ray give origin to the fifth pair, and are very distinct in the pike, trout, salmon, and perch. These tubercles are peculiar to this class.

The cavities in the interior of the optic eminences in Birds, Reptiles, and Fishes, are observed in the fœtal brain of the MAMMALIA during its early growth.

It is almost superfluous to mention, that, in the two warm-blooded classes, Mammalia and Birds, the brain, with its investments, fills completely the cranial and vertebral cavities. In the Reptiles, however, in which the brain does not approach the cranial walls, we remark the first departure from this arrangement; and in the Fishes it is so completely violated that the brain and chord occupy but a small proportion of the cranio-vertebral cavity; and between the former and the osseous walls there is a quantity of fine but very loose filamentous tissue, containing in its cells a large quantity of pellucid fluid. Though this arrangement gives this the appearance of a white jelly-like substance, it is not gelatinous, as is generally represented, but merely a pellucid fluid, sometimes pale straw-coloured, occasionally with a reddish tint, contained in numerous communicating cavities of a tissue which appears to represent the arachnoid of the warm-blooded animals.

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The *pia mater* in the reptiles and fishes is reduced to a filamento-vascular web, accompanying the blood-vessels.

The *dura mater* undergoes some peculiar modifications in different orders. In the duckbill a bony plate is contained between the *laminæ* of the falx; and the same structure is found in the porpoise, perhaps in the other CETACEA. An osseous *tentorium* with a quadrangular aperture is found in the coaïta and marten, and the feline and ursine families; and an osseous partition consisting of three parts is found in the dog, horse, Cape ant-eater (*orycteropus*), the wombat, and the seal. The bony *tentorium* is also found in the woodcock and others of the feathered class. In the red but cold-blooded animals the *dura mater* forms neither falciform nor tentorial process.

On the nerves or ramified chords of the nervous system a few words must suffice. In fishes the tenth or pneumogastric consists not of a common trunk, but of three orders of filaments, the first and largest of which are distributed to the gills, and correspond to the pulmonary nerves of the MAMMALIA; the second, slender, are distributed to the muscles of the tongue and the surface of the *œsophagus;* and the third terminate in a large nerve which traverses the body longitudinally immediately beneath the lateral line. The phrenic nerve is wanting in birds, reptiles, and fishes.

In the MOLLUSCA the nervous system consists of a number of whitish cerebral masses distributed in different parts of the body, with one or two more conspicuous than the rest, and supposed therefore to represent the brain, placed transversely over the œsophagus, which it encompasses with a nervous collar.

In the ARTICULATA the nervous system consists of two long chords extending along the belly, and expanded at various intervals into gangliform knots or enlargements. The first of these, which is situate on the œsophagus, rarely exceeds the others in size. Among the ZOOPHYTES hitherto examined the nervous system assumes either a radiated or an arborescent form.

PART II.

COMPARATIVE ANATOMY OF THE ENTROPHIC ORGANS.

CHAP. I. THE LIMITROPHIC ORGANS.—SECT. I. THE ORGANS OF DIGESTION.—§ 1. THE TEETH.

Though genuine teeth are found in three classes of animals only, viz. the MAMMALIA, the REPTILES, and the FISHES, yet all the orders of these classes are not provided with teeth. Thus, among the first class, the ant-eater tribe, the pangolin, the *echidna* and *ornithorhyncus*, and the whales—among the second the *cheloniads*—and among the third the sturgeon—are altogether destitute of these organs. In all the invertebrated classes, the jaws, when present, are provided with notches varying in number. The *echinodermata* alone have genuine teeth, inserted in a mechanical apparatus very different from ordinary jaws.

Though in general structure the teeth of the lower animals resemble those of man, in some respects they differ considerably. These varieties consist either in some change or modification of the constituent parts of the teeth, or in the addition of some other substance to those parts.

The first variety to be noticed is of the former description.

Bone of tooth.

Though in the QUADRUMANA and ZOOPHAGA the bony matter of the teeth is quite similar to that of man, in other orders this substance appears in the form of a very hard, compact, and more regularly fibrous substance than bone, and to which the name of ivory (*ebur*) is applied. It is chiefly in the canine or tearing teeth that this substance is found to represent the bony pillar of the teeth; and it is principally among the PACHYDERMATA, and some of the AMPHIBIA and CETACEA, that this change is observed.

Ivory of different animals.

The ivory of the elephant is the most tender, and that which most rapidly becomes yellow on exposure to air. It is readily distinguished from the ivory of other animals by the curve lines which radiate from the centre to the circumference of the tooth in various directions, and which form by intersection regular curvilinear lozenges.

The ivory of the hippopotamus is greatly harder and whiter, and is on that account preferably employed for the preparation of artificial teeth. A transverse section of this substance shows *striæ* extremely delicate and regular. In this animal, also, not only the canine but the incisor teeth consist of this substance. The tusks of the Ethiopian boar (*sus Æthiopicus*) consist of ivory similar to that of the hippopotamus. In those of the ordinary boar, though no *striæ* are recognised, there is sometimes a mixture of brown substance disposed in layers. The ivory of the teeth of the morse, though void of *striæ*, is compact and susceptible of polish nearly as brilliant as that of the hippopotamus; and its character is, that the central pillar of the tooth consists of minute round grains, indiscriminately aggregated, like pebbles in puddingstone. The axis or pillar of the molar teeth of this animal, which are without internal cavity, consists of similar minute grains. The ivory of the dugong is homogeneous and without *striæ*. That of the teeth of the white whale or cachalot resembles the bone of human teeth in its satin-like appearance. The ivory of the tusk of the narwal is very compact and homogeneous in appearance.

The most singular structure of teeth among quadrupeds is observed in those of the Cape ant-eater (*orycteropus*). The teeth of this animal, which have the appearance of two cylinders conjoined, consist of an infinite number of minute straight parallel tubes, so that their transverse section resembles that of a rush. As these tubes are closed only at the triturating surface, it is there only that the tissue of the tooth is compact; and when the enamel is worn, the upper orifices of these tubes begin to be exposed. There is, therefore, no general cavity in the interior of the tooth. These teeth are also void of root. A similar tubular structure is observed in the two molar teeth of the *ornithorhyncus*, and in the teeth of some fishes.

Enamel.

The enamel (*lamella vitrea, cortex striatus*) presents peculiarities in the lower animals, as well as the bone of the tooth.

While the enamel of the human tooth is confined to the crown, in several of the lower animals, as the morse, it envelopes the tooth all round; and in the molar teeth of this animal, which, indeed, are void of cavity, it is thicker under the root than at the crown. A similar arrangement is observed in the old or adult teeth of the cachalot, which, when their cavity is obliterated by the full deposition of osseous substance, are also covered with enamel below.

The texture or constitution of the enamel is best seen in the grinders of the elephant. The section of a tooth in the germ exhibits fibres similar to those of asbestos or fine velvet. The fracture of the enamel is more distinctly fibrous than that of the bone, and the fibres are everywhere perpendicular, or nearly so, to the surface of

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the tooth. The hardness of this substance may be inferred from the fact that it strikes fire with steel. These component fibres, however, are not always rectilineal. Most frequently they describe curves with the convexity of incurvation towards the crown and the concavity towards the root. This arrangement at least is observed in the ruminants. The distinction between the enamel and bony matter is recognised by a gray line, and another whiter which belongs to the latter substance.

The enamel varies chiefly in thickness in different animals. The tusks which project from the mouth are generally observed to be less white, less hard, and more similar to bone or ivory than the other teeth; and on this account, probably, the existence of enamel has been denied in the tusks of the elephant. It is nevertheless certain that the external layer of these tusks presents radiating fibres, though it is by no means so hard, or possesses the same grain, as the enamel of the other teeth. Enamel is more apparent, though thinner, in the tusks of the morse, dugong, and boar; and it is quite as distinct in those of the hippopotamus as in the other teeth of that animal. Lastly, the enamel of the teeth of the cachalot, which is very thick, shows in its section only *striæ* parallel to the surface of the osseous substance.

Simple teeth.

Teeth may be distinguished according to the mode in which their component tissues are arranged into three sorts. 1*st*, When the enamel invests the axis all round, and does not penetrate the latter, the tooth is said to be *simple* (*dens simplex*). Such is the character of the human teeth, and those of the QUADRUMANA and ZOOPHAGA, and several other animals, and all the reptiles.

Compound teeth.

2*d*, When the enamel is folded as it were round the bony part, but without inclosing it, so that the latter forms a continuous band several times folded on itself, and sections of the tooth in every direction divide repeatedly the component substances, the tooth is said to be compound or complex (*dens multiplex vel compositus*). A good example of this structure is seen in the grinders of the elephant.

Semicompound teeth.

3*d*, When the base or root of the tooth is simple, and the folds of the enamel and bone penetrate only to a certain depth, they are said to be semicompound. Examples of this modification of arrangement are seen in the grinders of the ruminating animals.

In the compound, and part of the semicompound teeth, the enamel is covered by a third substance; and as the latter is arranged, especially in the former sort, so as to leave intervals between it and the next layer of enamel, this substance serves to fill all these intervals, and consolidates the component lobes of the tooth even before their osseous parts are united below. This substance, which is denominated by Cuvier *cement*, by Tenon *cortex osseus*, and by Blake *crusta petrosa*, though less firm than either bone or enamel, is dissolved by acids more slowly than the former, and sooner becomes black in the fire. In the teeth of the elephant and *cabiai* it forms half their mass at least. In most *genera* it presents no apparent organization, and resembles a sort of crystalline tartar incrusted on the tooth. In the cabiai, however, it presents numerous pores very regularly arranged. Tenon was of opinion that it arose from ossification of the membrane which enveloped the tooth; blake ascribed it to deposition from the opposite surface of the enamel membrane; but Cuvier ascertained that it is deposited by the same membrane and the same surface as the enamel. This accurate observer found, on inspecting the germs of the teeth of the elephant, that when the internal membrane of the dental capsule has deposited the enamel, it undergoes a change of structure, and becomes thick, spongy, opaque, and reddish, to furnish the cement, which is then deposited, not in regular crystalline fibres, but in random drops.

The cement or *crusta petrosa*.

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The teeth of the Reptiles consist of hard, compact, osseous matter, invested by a thin covering of enamel, and without cement.

Teeth of fishes.

The teeth of Fishes vary much in structure. They are either simple or compound. The simple teeth are those which consist of bone invested by enamel. They may be distinguished into two species, according to their mode of attachment. The first are the simple teeth, which are not implanted in *alveoli*, but merely attached to the gum, or fixed by articulation to the jaw, as those of the shark tribe; the second are simple teeth growing in alveolar cavities, as is observed in the majority of fishes, the pike, dory, &c. The simple teeth attached to the gum are chiefly distinguished by their fibres intersecting in the manner of the cancellated tissue of bones, and being therefore at first light, porous, and spongy, and becoming afterwards uniformly hard and compact like ivory.

The compound teeth, which consist of an infinite number of minute tubes mutually aggregated and invested by a common covering of enamel, form plates of different sizes, adhering to the bones of the jaws or palate by an intermediate membrane only. In some they affect the disposition of the quincunx; in others they occupy the whole breadth of the upper jaw at least, as in the ray as seen on the small scale, and in the same manner in larger fishes; others are in straight transverse bars; others assume the shape of a circular segment, or the figure in heraldry denominated the chevron.

In the wolf-fish the jaws are provided with eminences composed of fibres or tubes proceeding from the base to the circumference, and which are connected to the jaw by a substance more spongy than the rest of the bone.

Mechanical detrition of the teeth.

After their first formation the teeth retain nearly their original shape in the ZOOPHAGA, man, and the QUADRUMANA. In the two latter only their crowns begin to be worn, rendering the incisor and canine less pointed by the use of food partly vegetable; but in the zoophagous tribes they undergo no detrition whatever. In the herbivorous animals, however, the crown begins to undergo detrition more or less rapidly; and in no long time the superior layer of enamel is entirely worn off, and the surface of the tooth exposes the succession of bone or ivory, enamel, and cement. These substances are well seen in the teeth of the RODENTIA, for instance the hare; those of the PACHYDERMATA, as the elephant; the Ruminants, as the stag, sheep, and ox; and the SOLIDUNGULA, as the horse. In all these animals the enamel, which is hardest, forms prominent lines or ridges; while the bone and cement are indicated by depressions.

Successive dentition of the elephant.

This detrition, which is purely mechanical, might proceed to such an extent in the herbivorous quadrupeds as to destroy the whole of the crown of the tooth, and leave the process of mastication to be performed by the jaws only. It appears to be chiefly to obviate this inconvenience that the dentition of the elephant, the Ethiopian boar, and perhaps all the PACHYDERMATA, is conducted in a successive manner through a series of six or eight sets of teeth at least. In the former animal, in which this process has been best observed, and was ably explained many years ago by Mr John Corse Scott (*Phil. Trans.* 1799), each half-jaw, whatever it contains, exhibits at one time only one complete grinder and part of another behind it, the prominent parts of which are placed obliquely to the horizon, forming an inclined plane, so that the anterior parts are worn before the posterior. The anterior complete one, which is employed in mastication, undergoes progressive detrition till its anterior portion is worn down to the level of the jaw. In this state the fangs of the anterior part of the tooth begin to diminish, rendering the tooth narrow before; while the crown of the poste-

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rior begins to be worn, and undergoing the same detrition, the posterior fangs also begin to give way. While this process, however, is advancing, the posterior tooth, of which only the anterior part was appearing above the gum, gradually rises, with its crown forming a plane inclined from before backwards, similar to that of the anterior grinder. When this posterior tooth has been raised sufficiently to allow its anterior margin to be used in mastication, the residue of the anterior tooth drops out altogether, and the posterior one continues to rise and advance rapidly, until it is completed, when it is found to be much larger than the previous tooth, and to consist of a greater number of plates of ivory and enamel (*denticuli*). In no long time this new tooth, which undergoes the same process of detrition, is succeeded by another one, the anterior margin of which rises first behind the posterior one of its predecessor, and which passes through the same stages of growth, detrition, and shedding. This process is repeated at least seven or eight times, and each succeeding tooth is larger, and contains a greater number of ivory and enamel plates than its predecessor. The elephant has thus 7 or 8 grinders in each half-jaw, or 28 or 32 grinders respectively; yet there are never more than one tooth and part of another, or at most two, that is, eight teeth in the upper and lower jaws, at the same time. Though the disappearance of the fangs of the anterior tooth is ascribed to absorption—which indeed is a good general name—yet the true reason is the fact that the maxillary or dental vessels of the elephant are unable to sustain more than one tooth in each half-jaw at once; and that since these vessels gradually transfer their blood to the new tooth, while those of the old one shrink and are obliterated, the new tooth grows as the old one is actually dehematised or atrophied. The order in which the teeth of the elephant succeed each other is nearly the following. The first or milk grinder, composed of 4 eburneo-vitreous plates (*denticuli*), cuts the gum eight or ten days after birth, is well formed in six weeks, and completely out in three months. The second, which consists of 8 or 9 plates, is completely exposed at the age of two years; the third, consisting of 12 or 13 plates, at six years. The fourth to the eighth grinder consist of plates varying in number from 15 to 23; but the period at which these teeth appear has not yet been determined. This process has been shown to have taken place also in the gigantic fossil animal named the *mastodon*.

A similar process of displacement and renovation takes place in the poison-teeth of serpents, and in the teeth of the shark, *diodon*, and *tetraodon* tribes. In the wolf-fish (*anarrhicas lupus*) the teeth are shed along with the spongy membrane in which they are contained, exactly as the horns of the stag.

Dentition of the horse.

In the horse, in which the process of dentition has been carefully observed, it is usefully employed to determine the age of the animal. The milk incisors appear at the end of 15 days; the four middle ones, or the *nippers*, are shed at 30 months; the four following ones at 42 months; and the four external, or the corner teeth, at 54 months. The permanent corner teeth do not grow so quickly as the other incisors; and by these especially the age of the horse is determined. At first they scarcely rise above the jaw. Their middle then presents a hollow filled with blackish tartar, the margins of which are worn down as the tooth rises from the gum, and is rubbed against the corresponding one; and it diminishes progressively from 54 months to 8 years, when it is altogether obliterated. The hollow of the other incisors is obliterated at a later period than that of the corner ones; and the age of the animal is then estimated from the length of the incisors, which continue to increase.

The first two molar teeth appear in each jaw and on each side about the 8th day, the next at the 20th, and the complementary or small anterior grinder about the 5th or 6th month. The first posterior molar appears about the 11th month, and the second in the 20th. At the 30th or 32d month the first two milk grinders are shed, the third in the 3d year; and about the 5th or 6th year the last posterior grinder appears. The milk grinders are longer from before backwards than the permanent ones, which are themselves contracted in this direction, as they are pressed by the posterior grinders; from which it results that the dental crowns of young horses are oblong, while those of the old are quadrangular.

In the MAMMALIA the teeth are always implanted in the jaw-bones, and never, as in other animals, in the tongue, palate, &c. The only exception to this rule is the *echidna*.

Arrangement of the teeth.

The three kinds of teeth, incisor, tearing, and grinder, are found together only in Man, the QUADRUMANA, the ZOOPHAGA, the PACHYDERMATA except the elephant and two-horned rhinoceros, in the hornless Ruminants, and in the SOLIDUNGULA; but, of all these animals, in man only are the three forms of teeth arranged in an uninterrupted series, and in such a manner that those of the lower jaw are applied to those of the upper. In one other animal only, now extinct, the *anoplotherium*, is this continuity of arrangement observed.

In the QUADRUMANA and ZOOPHAGA, and all those in which the canine are larger than the other teeth, there is a gap on each side of the jaw to receive the canine of the opposite one. In the ursine genus there is a large empty space behind each canine tooth. In the hedgehog, shrew, phalanger, and tarsier, in which the canine are shorter than the other teeth, a space is left between them and those opposite. In the maki tribe, proper bat, colugo, and camel, there is a large interval between the upper incisors. Lastly, the Ruminants want the incisors of the upper jaw, and the morse those of the lower.

Some animals provided with the three classes of teeth lose the incisors at a certain age; for instance several of the bat tribe, and the Ethiopian hog. Other Mammalia have only two sorts of teeth, for instance incisors and grinders, separated by an interval without canine, as the wombat and all the RODENTIA, in which there are only 2 incisors in each jaw; the kangaroo, which has two below and 6 or 8 above; and the cavy or *hyrax* genus, which have 2 above and 4 below. The elephant has grinders and two tusks planted in the superior intermaxillary bone, but no inferior incisors or canine teeth.

Animals may possess grinders and canine teeth without incisors, as the sloth tribe and the dugong. The grinders, which are most essential, are most rarely wanting; and when others are deficient these are present, as in the armadillo tribe, the *orycteropus*, the *ornithorhyncus*, two-horned rhinoceros, and lamantin. The jaws of the dolphin are provided with uniform conical teeth all round, while the cachalot or white whale has them in the lower jaw only. In the narwal there are only two long spiral tusks implanted in the intermaxillary bone, and of these one is often wanting.

Absence of the teeth.

Lastly, teeth are entirely wanting in the ant-eater tribe, pangolin, and *echidna*, which are therefore arranged among the EDENTATA. In the whale the teeth are represented by plates of the laminated, fibrous, bluish substance distinguished by the name of *whale-bone*.

§ 2. ORGANS OF INSALIVATION.

Under this head ought to be noticed the modification which the salivary glands undergo in the lower animals. Our limited space, however, obliges us to proceed immediately to notice the peculiarities of the other divisions of the alimentary canal.

Comparative Anatomy. Œsophagus

§ 3. ŒSOPHAGUS, STOMACH, AND INTESTINAL TUBE.

The muscular tissue of the œsophagus consists, in most of the Mammalia, of spiral fibres twisted in two opposite directions, the external from before backwards, the internal from behind forwards. This arrangement, which was first observed in the RUMINANTIA, was supposed to explain the process of rumination. This opinion, however, is refuted by the fact that the arrangement is not confined to this order, but is very general among the zoophagous and other animals which do not ruminate. In the kangaroo the direction of these fibres is, as in man, transverse in the internal layer, and longitudinal in the external.

The œsophageal mucous membrane is covered by epidermis, which extends to the cardiac opening of the stomach in man, the QUADRUMANA, and all the ZOOPHAGA. This membrane, as well as the mucous, is thrown, by the action of the muscular tunic, into longitudinal folds, which are effaced only when the œsophagus is distended. In the tiger, lion, and lynx, there are large transverse valvular folds, and smaller ones in the civet and couguar—an arrangement connected probably with the carnivorous habit.

Stomach. The stomachs of the lower animals vary considerably in shape, in the insertion of the œsophagus, in the disposition of their muscular tunics, and in the simplicity or complication of their cavities. These characters it is impossible in such a sketch as the present to consider in detail; and we shall confine our attention to those peculiarities which are most striking in the digestive organs of the animal world.

Simple stomach. The stomachs of the MAMMALIA may be distinguished into the simple and compound. Those of man, the QUADRUMANA, zoophagous and most of the herbivorous tribes, belong to the former order. This simple form of stomach, however, may be generally distinguished into two parts, a cardiac and a pyloric, more or less separated from its other by a central transverse contraction of its annular muscular fibres. This is particularly seen in the horse, man, murine family, and many other animals which occasionally feed both on animal and vegetable matter. In the human stomach this contraction is represented in Plate XXXVI. fig. 4. In the porcupine, however, there are three pouches. This contraction depends on a strong annular band of muscular fibres at this part of the organ. In the pure carnivorous animals, however, as the feline family, the annular fibres, which are very thick, are nearly equally so from the cardiac to the pyloric end.

The compound stomachs, or those which contain more cavities than one, are found in the sloths, and the ruminant and cetaceous animals chiefly.

Bicular stomach. In the first tribe the stomach of the *Unau*, or two-toed sloth, is two-fold. The first cavity is large and globular, but tapering behind into a conical appendage, separated by a semilunar fold; while a large cul de sac on the left of the *cardia* opens into a canal which proceeds at first backwards, and then turning to the right, enters the second cavity by a narrow aperture. The second, which is small, tubular, and folded under the former from left to right, is distinguished by a semilunar fold into two halves, the first of which opens into a small cul de sac on the right side of the first cavity. The inner membrane of both cavities is smooth, and without *villi*. A similar arrangement is found in the *Ai*, or three-toed sloth, with this exception, that the appendage of the second gastric cavity is divided into three compartments by two longitudinal bands. This canal seems analogous to the arrangement of the ruminating stomachs, in so far as it may allow the alimentary matters to pass occasionally from the œsophagus directly into the second stomach.

The stomach of the *hyrax*, ashkoko, or Cape cavy, also consists of two pouches, separated by a middle partition, in which there is an aperture for mutual communication. In the hippopotamus the cardia communicates with three pouches, two of which only are cognizable without, and with a long tubular bowel, the interior of which is divided across by several valvular folds.

In the kangaroo the stomach receives the œsophagus near its left extremity, which is small and bifid (Plate XXXV. fig. 8); and forming a larger cavity on the right, passes upwards, making a turn, and crosses to the left before the œsophagus, makes another turn, and again crosses the mesial plane to the right, where it terminates in a tapering cavity at the pylorus. In this course it presents internally a longitudinal band (L, L, L), extending all round to near the pyloric end, and crossed by valvular membranous folds, which divide the cavity into cells not unlike those of the colon, especially in the horse. The mucous epidermis is continued from the œsophagus over the space marked *c*, *c*.

Quadrilocular stomach of the ruminants. The stomach of the Ruminants consists of four distinct but communicating cavities. The first, denominated the Paunch (κοιλια, *rumen*, *penula*, *ingluvies*; *la panse*, *l'herbier*, *la double*), is a large bag occupying the left side of the abdomen chiefly, marked externally by two saccular appendages, and separated within into four parts. (Plate XXXV. fig. 1, A, A, A, A.) Its inner surface, upon which the epidermis is continued, is occupied by flat *papillæ*. By a pretty wide aperture (B, B), with rounded margins, this communicates with the second cavity named the Kingshood (κεκρυφαλος, *reticulum*, *le bonnet*), which is distinguished by the rhomboidal and polygonal cells, into which its inner membrane is moulded. An aperture at the further end of this (C) leads into the third or smallest cavity, termed the Maniplies (εχινος, *omasum*, *le feuillet*), from the numerous concentric crescentic folds formed by its inner membrane (fig. 2, *c* and P). These folds amount to about 40 in the sheep and 100 in the ox. The smallest of them, between the aperture from the second into the third cavity, are puckered or collected towards their further end by a transverse membranous fold, which acts as a valve to the aperture between this and the fourth cavity. This one, generally named the Red (ηνυστρον, *abomasum*, *la caillette*), is of an elongated pyriform shape, slightly incurvated on itself (fig. 2, D), and is marked internally by longitudinal folds (P) incurvated according to the curvature of the cavity itself, and terminating near the pyloric end in *rugæ* or irregular duplicatures (R). This is the structure of the gastric cavities in the ox.

In the camel, dromedary, and lama, the stomach is equally complicated, though the structure is a little different. In the first of these animals, which may be taken as an example of the others, the Paunch or first cavity is a large bag, divided into two compartments on the posterior part, by a strong band passing from the right side of the cardiac orifice longitudinally downwards (L, L, fig. 3), and forming one border of a groove leading to the orifice of the second. From the left margin of this band proceed eight muscular bands, nearly at right angles, and intersecting with others, form cellular cavities on the left side of the paunch (N); while on the right side there are similar cells, though smaller, and wholly unconnected with the longitudinal band. From the left margin of the cardia, in like manner, proceeds a broad muscular band (M, fig. 3) to the aperture (B) of the Paunch into the Kingshood, after which it takes another direction (M, fig. 4) towards the Maniplies or third cavity, within the orifice of which it terminates (C, fig. 4). The Red or fourth chamber is much the same as that of the bullock (D, P, R, fig. 5), and the only peculiarity is, that after terminating in (Π) the pylorus, it opens in a small cavity (O) which leads into the duodenum (Δ).

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Water-cells of the camel.

From this description, for the particulars of which we are indebted to the accurate account of Sir E. Home, it results that the stomach of the camel differs from that of the ox and other horned ruminants chiefly in the possession of the quadrilateral cells in the second stomach. Into these the water is conveyed by the animal when drinking, and in these it remains. By the action of the muscular band (M), the aperture between the Paunch and Kingshood is opened, and the water is directed into it so as to fill its cells. When these are filled the surplus runs off into those of the first stomach, where at least those on the left side of the long band may be regarded as part of the general cellular structure. These cells are represented of a large size in fig. 5, in which they appear like oblongs with rounded corners. They are always larger on the left side of the band, in the Paunch, than those in the second stomach.

Both in the bullock and in the camel, and in all the Ruminants, the first and second stomachs only are covered by mucous *epidermis*.

Quadrilocular stomach of the CETACEA.

In the Cetaceous animals similar complication of the gastric cavities is observed. In the bottle-nose porpoise, which may be taken as an example, the œsophagus, which is large and capacious, terminates in a spheroidal or ovoidal flask-like bag (fig. 6, A, A) with an aperture a little below the cardiac, consisting of rose-like annular folds, and leading into a second cavity. This, which corresponds to the ruminant kingshood, is nearly spherical in shape (fig. 7, B), and presents valvular folds more circular than in the ruminants, and intersected by others so as to give it the honeycomb appearance characteristic of this cavity. From this another aperture leads into the smallest cavity of the three (C, fig. 7); and thence into the fourth, which is long, cylindrical, and slightly incurvated. The third cavity is remarkable for presenting in its inner membrane numerous apertures of mucous glands.

Crop of birds.

Birds are distinguished by possessing a stomach consisting of three cavities. The first is the crop, which may be regarded as a mere expansion of the œsophagus, and confined chiefly to land birds. It is filled not only with food, but with small stones; and its chief purpose seems, by mechanical comminution, to supply the place of the teeth in dividing the granular aliment, and bruising or killing the animals swallowed. It is found chiefly in the granivorous birds. It is wanting in the ostrich, in the piscivorous birds, and most of the GRALLÆ.

Glandular crop.

The second is the glandular crop or subsidiary stomach (*ventriculus succenturiatus, bulbus glandulosus*), a membrano-glandular sac, which may be also regarded as an œsophageal dilatation. It is larger when the crop is wanting; and though, when conjoined with it, it is always very glandular, and may be therefore regarded as a chemical solvent of alimentary substances, it appears to supply the want of the crop, which is certainly chiefly a mechanical apparatus. The glandular crop or subsidiary stomach is remarkable for the number and size of the glandular bodies contained between its mucous and muscular tunics. These glands, though variable in shape, are generally conical; and some consist of several glands conjoined in one common peduncle (Plate XXXVI. fig. 3). All of them are hollow, and secrete a fluid which is discharged by one or more minute apertures, and which is of essential importance in the solution of the food. In some instances, as in the American ostrich (fig. 2), they are few in number, and occupy only a small part of the posterior wall of the œsophagus.

Gizzard.

The gizzard or proper stomach of birds may be considered as a horny mucous membrane, somewhat cartilaginous, continuous with that of the œsophagus, and covered by two strong thick muscles, the fibres of which converge to a point. (Plate XXXVI. fig. 1.) In the carnivorous and piscivorous *genera* of birds, especially those in which the crop is wanting, the gizzard loses its muscular character, and is converted into a membranous pouch.

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Reptile stomach.

The stomach of REPTILES does not present those dilatations observed in BIRDS; and when it changes its diameter or capacity, it is only progressively and insensibly. Its general diameter, nevertheless, is proportionally larger than in the two classes already noticed. Most generally without *cul de sac*, its shape is spheroidal, more or less oblong; its membranous walls are thin and transparent; its muscular layer almost imperceptible; the cellular identified with the mucous tissue; the situation of the *cardia* indeterminate; and the *pylorus*, without valve, is distinguished by a simple tapering contraction of the gastric walls, and the appearance of the structure proper to the intestines.

In this class of animals, further, digestion appears to be less regulated by fixed principles than in the other two. It is evidently not confined exclusively to the stomach. The œsophagus of the turtle is provided with numerous large, firm, pointed processes, which in all probability contribute to the mechanical division of the food, so much the more requisite as the CHELONIAD REPTILES are toothless. Except in the crocodile, the SAURIAL Reptiles are destitute of large arch or proper cardiac cavity. In the OPHIDIAL or Serpentine Reptiles the stomach has the figure merely of a dilated sac between the œsophagus and intestines, and presents no curvature. It is probably in connection with this modification of structure that we find animals remain for days in the œsophagus of serpents; and this tube appears to be to a certain extent capable of digesting aliment as much as the stomach. The best mark of distinction in such circumstances is the cessation of *epidermis*.

Stomach of fishes.

In no class of animals does the stomach vary more in shape, structure, and situation, than in FISHES; and perhaps the general character of the alimentary canal in this class is most justly given by representing it as deviating from those attributes of regularity which we find in the higher classes. While in the MAMMALIA and BIRDS it is always distinguished by its spheroidal or pyriform enlargement between two tapering extremities, and by being much more dilated than any other part of the alimentary canal, in the Reptile class it begins to part with this character; and it loses it altogether in the Fishes. In most of the finny tribes it is often not more capacious than the œsophagus; and it is distinguished from this tube only by the villous character of its internal membrane. In general, also, the situation of this pyriform dilated sac is transversely across the body in the Mammiferous class. In the feathered tribes this character also is slightly set aside, and partly from the alteration in shape, partly from that of position, the stomach occupies less of the transverse diameter than of the longitudinal extent of the body. Among the Reptiles this character, though still retained in the CHELONIAD, and even in the SAURIAL, is gradually enfeebled in the OPHIDIAL; and in the FISHES it may be said to be entirely obliterated, since the organ occupies much more longitudinal extent than transverse width of the body.

The first character of the alimentary tube of fishes is the width or capacity combined with shortness of the œsophagus. The latter character is manifestly associated with the absence of lungs and consequent want of chest; so that between the throat and abdominal cavity, the interval, which corresponds only to the space occupied by the heart, is extremely abridged. The œsophagus consists, as in the other classes, of a mucous membrane surrounded by a muscular tunic; but the mucous membrane is distinguished by the firmness and whiteness of its corion, which in some *genera* approaches to the consistence of horn or cartilage, and by the presence of conical *papillæ*, sometimes of great hardness, and which appear to

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act mechanically on the food. It is almost superfluous to notice the facility which the large capacity of this tube affords fishes for swallowing their prey. Most of them are voracious in the extreme; and it is not uncommon to find the stomach and œsophagus crammed to the throat.

The figure and position of the stomach of Fishes are so variable, that it is difficult to give a character of general application. Though in many *genera*, especially of the JUGULARES, it consists of a cylindrical sac with a slight dilatation immediately below the *cardia*, in others it is oblong ovoidal, as the ray and shark tribe; and in others, as the sole, dory, and flat fishes generally, it is orbicular. In the sturgeon it consists of a cylindrical tube incurvated twice on itself. In none is there more than one *cul de sac*, the depth of which varies as the part corresponding to the *pylorus* is more or less remote from the *fundus*. When the limits of the stomach are indistinct, the situation of the cardia is equally so. In the lamprey (*petromyzon*) and pen-fish (*syngnathus pelagicus*) the whole tube is of a uniform size from the mouth to the anus; and much the same may be said of the carp genus. The genera in which it forms a distinct dilatation or cul de sac are chiefly the following; the eel (*muræna anguilla*), conger (*m. conger*), the bullhead *genus* (*cottus*), the *scorpæna horrida*, *labrus genus*, perch, cuckoo gurnard, mackerel, herring, salmon, *mormyrus genus*, mullet, and *silurus Bagre*. In the anableps the dilatation disappears; and in the *chætodon ciliaris* and some others it is a large sac incurvated in an arch-like bend.

The intestinal canal in most of the Mammalia is very similar to that of man; and the chief differences of different orders and genera are found in the difference of longitudinal extent either of the whole intestinal tube or the comparative lengths of its several parts.

Comparative length of the intestine to the body.

From the time of Grew to that of Cuvier, and most modern anatomists, it has been a point of some importance to determine the length of the intestinal tube in relation to that of the body. This comparative length, which is greatest in the MAMMALIA, diminishes successively in the BIRDS, REPTILES, and FISHES. It has been occasionally stated by different anatomists, that the intestinal tube is longer, *cæteris paribus*, in granivorous than in carnivorous animals, and conversely. When we come, however, to compare the different lengths of this tube in the several tribes, we find that this statement demands modification. In the ape family its length varies from 5 to 8 times that of the body; in several of the *lemur* tribe from 4 to 6 times, the smaller length being in this case compensated by the size of the *cæcum*; and in others of the lemur tribe, *e. g.* the *lori*, the intestine is only three times the length of the body. Among the CHIROPTERA there are two examples of very great contrast in this respect. While the intestine of the *noctula* or great bat (*vespertilio noctula*, Lin.) is the shortest of all the MAMMALIA, and scarcely does more than exceed the length of the animal's body, that of the roussette (*pteropus*) or East India bat, which lives chiefly on vegetable matter, is at least 7 times longer than its body. A similar instance of the meeting of extremes is found in the Marsupial order, in which the marmoset and cayopollin have intestines only $2\frac{1}{2}$ times longer than the body, while that of the phalanger is more than 11 times longer. In the plantigrade or ursine family, which occasionally live on vegetable matters, the proportional length approaches to that of the ape.

In the carnivorous animals the intestine, though generally short, varies from 3 times to 8 times the length of the body. The former is the proportion in the lion, wild cat, ocelot, couguar, and weasel; and the latter in the hyena. Some of them also vary among themselves. Thus the intestine of the wild cat is greatly less than that of the domestic animal. The proportion is very great among the RODENTIA, in several of which it is 8, 10, 12, or 16 times longer, as in the agouti, than the body of the animal. Among the murine tribe, however, it undergoes a diminution. Among the EDENTATA, again, especially the sloth tribe, it diminishes very much, being only about $3\frac{1}{2}$ times longer than the body in the *Ai* and *Unau*. This brevity is so much the more extraordinary that these animals are void of cæcum, and live on vegetable matters; but, in all probability, the duplicature of the gastric cavities in some degree compensates this deficiency.

The intestinal tube attains its greatest proportional length in the Ruminant animals, being at least 11 times longer than the body, as in the goat, and 28 times longer in the ram. This immense length is supposed to compensate the absence of dilatation in the large intestines, and the small size of the cæcum. In the SOLIDUNGULA, again, which are remarkable for the large size of the cæcum, the length of the intestine diminishes much, being 8 times longer than the body in the zebra, 9 times in the ass, and 10 times in the horse.

Lastly, it is a singular circumstance, that in different species of the same genus the comparative length varies much. We have already noticed the difference between the length of the intestine in the wild and in the domestic cat. The wild and tame boar is a similar instance of the same, the intestine being only 9 times longer than the body in the former, and so much as $13\frac{1}{2}$ times in the latter. It is possible that such differences may depend on the different habits of the animal in his wild and domestic condition. This explanation, however, is totally inadequate to account for the difference in the comparative length of the intestinal tube in the Asiatic and African elephant, being 10 times longer than the body in the former species, and only 7 times in the latter. The same may be observed of two animals very closely allied, if not of the same *genus*, the *echidna* and *ornithorhyncus*. The intestine of the former animal is 7 times longer than his body, while that of the latter is only 5 times.

In BIRDS generally the intestine is shortest among those genera which prey on animals and fish; it varies from twice to five times the length of the body. In the gallinaceous and passerine birds, which live on grains, it is always longer and more capacious than in those which live on animal substances. In the cassowary, which is granivorous with a short intestine, the intestine is divided by contractions into distinct pouches, to compensate for the brevity of the tube. It must be remarked, nevertheless, that in several birds which prey on fishes, the intestinal tube is proportionally longer than in those which feed only on grain; and the proportional length is not diminished in birds living indiscriminately on animal and vegetable aliment.

The intestinal tube of the Reptiles is still shorter than that of Birds, and often it does not exceed twice the length of the body. It is longest in the CHELONIAD, and shortest in the RANINE and SERPENT tribe. In the tadpole, however, a singular peculiarity is observed. The intestinal tube of the tadpole of a frog is nearly ten times longer than the space between the muzzle and the vent (*anus*); whereas, after the animal has become a frog, the intestine is only twice as long as this space.

In the class of Fishes the intestinal tube is still shorter and more direct in its course to the vent or outlet. In a few which live chiefly on marine vegetables, for instance some of the *chætodon genus*, it is about six times longer than the body of the animal; and in a few of the carp *genus* (viz. *cyprinus capæta*) it amounts to ten or twelve times longer than the body. In others, however, of the same genus, for instance the *cyprinus mursa*, it is scarcely as long again, showing here once more an instance of the conjunction of extremes not easily explained.

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Distinction into *ileum* and *colon*.

In most vertebrated animals the intestinal tube may be distinguished by natural marks into two divisions, one extending between the pyloric end of the stomach to a part of the tube, where it becomes wider and more capacious; the other from this to the vent or outlet. In some instances, however, this distinction is very obscurely and imperfectly marked. In the MAMMALIA, in which the distinction is observed, it is indicated by one or more appendages, which, if large, are denominated *cæca*, and if slender and long, are termed *vermiform processes*. Man, the ourang, and the wombat (*phascolomys*), are the only animals which are possessed at once of *cæcum* and vermiform appendage. In the other genera of the ape tribe, in the maki of the *lemur*, in the colugo among the CHIROPTERA, the ichneumon, many of the carnivorous tribe, the opossum and kangaroo, the RODENTIA except the dormouse, the Cape ant-eater, the PACHYDERMATA except the hyrax, the Ruminants, SOLIDUNGULA, and AMPHIBIA, there is only a cæcum without vermiform process. The cæcum is wanting in the sloths, the bat tribe, the Ursine except the ichneumon, the marten, pine-marten, weasel, &c. the dormouse, and all the Cetaceous animals.

The presence of cæcum or vermiform process, however, is not necessary to distinguish the canal into two portions. The inner or mucous surface of the *ileum* is always villous and uniform; and the whole intestine, except its superior or pyloric portion, is convoluted in proportion to its length, and moves about freely in the abdominal cavity; whereas the colon is more or less fixed at different points, it is shorter and more capacious, and its inner membrane is merely mucous without long *villi*. A mark equally general is the semilunar duplicature of mucous membrane placed between the ileum and colon, and named the *ileo-colic* valve. In the sloth and armadillo tribes, which want cæcum and vermiform process, this and the slight difference of diameter are the only marks of distinction between the ileum and colon. In all the other MAMMALIA which are destitute of cæcum the whole tube is of the same calibre, occasionally diminished towards the vent; and the division into *ileum* and *colon* is no longer cognizable.

In all the MAMMALIA with one cæcum, it appears in the form of a production from the large intestine beyond the part at which it receives the *ileum;* and though variable in its diameter and structure, it bears a general resemblance to the colon in these respects. In herbivorous animals, and even in some that are omnivorous, as the ape and lemur tribes, it is generally large and puckered by tendinous bands. To this, however, an exception is observed in the Ruminants, in which the cæcum is moderate in size and unpuckered. It is small and unpuckered in the kangaroo-rat and wombat; while, conversely, in the colugo and brown phalanger, which are believed to be chiefly zoophagous, it is very large and puckered.

In the zoophagous animals generally both the *colon* and *cæcum* are of small calibre, little different from that of the *ileum;* and both the colon and cæcum are destitute of cells or compartments. In herbivorous and several omnivorous animals, on the contrary, the inner surface of the colon is divided by longitudinal and transverse bands into a number of cells or compartments. From this rule, however, there is an exception in the wombat, kangaroo, and the Ruminants. In the RODENTIA the colon is cellular at its commencement only.

In birds the canal is provided with two *cæca*, one on each side, not far from the vent. In the omnivorous and granivorous these *cæca* are generally long and capacious. While they are very large in the nocturnal predatory birds, they are either obliterated or wanting in the diurnal predatory birds, in the green woodpecker, the lark, and the cormorant. In the heron, bustard, and grebe, there is a single small one; in the cassowary two very slender; and in the merganser, diver, &c. they are short and thick.

In all birds the short bowel between the insertion of the *cæca* and the *cloaca* is a little wider and more capacious than those between the *pylorus* and the *cæca;* and this is the only circumstance which indicates in this class the distinction of the tube into *ileum* and *colon*.

In the reptiles the intestinal tube is generally void of *cæca* or appendage; and the only distinction consists in the one part of the tube, which is long and slender, being joined to another which is short and thick, and in the presence of a semilunar membranous fold at the point of insertion. In the *iguana* alone has a genuine *cæcum* been observed.

The distinction into small and large intestine, or *ileum* and *colon*, is still less obviously observed in the class of fishes. It sometimes happens that the difference of capacity is inverted, and that the calibre of the portion which terminates at the vent is actually smaller than that of the part connected with the stomach. This arrangement is observed in the ray, shark, sturgeon, and even the bichir; in the *syngnathus*, trunk-fish, and *balista*. In other instances the diameter is the same throughout; and the only distinction is derived from the anatomical characters of the inner membrane. In the lamprey, sea-devil, rough star-gazer, radiated sole, *holocentrus sago*, carp tribe, *mormyrus*, and mullet, it is impossible to distinguish the intestine into large and small.

Pyloric appendages of fishes.

FISHES resemble REPTILES in being destitute of *cæcum* at the junction of the small and large bowel. In many of them, however, there is attached to the intestine, somewhere below the *pylorus*, a variable number of small intestines terminating in blind ends, similar in size and structure to the intestine with which they communicate. These tubes, which have been not very happily named *pyloric* appendages (*appendices pyloricæ*), in so far as they are most frequently connected rather with the part of the bowel corresponding to the duodenum, vary in number from 2, 4, 6, or 8, to 80 or 180 in some genera, and even their number is not the same in different species of the same genus. Thus, while there are 6 in the smelt (*salmo eperlanus*), there are 68 in the *s. lacustris*, and 70 in the salmon (*s. salar*). In like manner, though there are 18 in the anchovy (*clupea encrasicolus*), there are 24 in the herring (*c. harengus*), and fourscore in the shad (*c. alosa*). In some, as the cod and pollach, they consist of several large trunks ramified into numerous small ones.

Peculiar form of the appendages.

These appendages, however, are wanting in the cartilaginous fishes with free *branchiæ*, in most of those with fixed *branchiæ*, in the APODES, and in several of the thoracic and abdominal order. In the sturgeon and some others they are represented by a series of communicating cavities inclosed in the intestinal membrane, which is covered by a cellulo-muscular tunic and peritoneum (Plate XXXVI. fig. 5), and which assumes the external appearance of a pancreas.

The spiral valve of fishes.

Among the cartilaginous fishes the brevity and directness of the intestinal tube is compensated by a peculiar disposition of the intestinal mucous membrane. This consists in part of the membrane projecting like a broad fold or process from the inner surface of the intestine, and winding round from the pyloric to the anal or lower extremity (fig. 7 and 8). This, which is denominated the spiral valve, may be easily understood from these figures, which represent the arrangement as it is observed in the shark. In the sturgeon, in which it is found in the last portion of intestine (fig. 6), its peculiarities have been described by the writer of this article in the *Wernerian Transactions*, vol. vi.

Rectum.

In all the MAMMALIA the intestinal tube terminates in a distinct bowel denominated the *rectum*, the mucous membrane of which is continuous with the skin at the

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anus. This rule can scarcely be said to be violated in the case of the *echidna* and *ornithorhyncus*, in which there is an aperture at the lower part for the urine and the semen of the male and the *ova* of the female. These anomalous and singular animals form a transition to the mode in which the intestinal tube terminates in the three genuine oviparous classes. In BIRDS, REPTILES, and most of the cartilaginous FISHES, the intestinal tube terminates in an outlet common to it with the urinary organs, denominated generally the *cloaca*. In the sturgeon, however, it has been shown, in the paper already mentioned, that there is a distinct urinary outlet; and that consequently this animal cannot be said to have a *cloaca*. In the greater part of fishes, while there is one vent for the excrement, there is another common one for the urine, the *ova*, and the spawn.

Cloaca.

On the subject of the liver, spleen, and pancreas, it is impossible to enter with any interest in this sketch.

CHAP. II. SECT. I.—THE HEMATROPHIC ORGANS.

The Mammalia and Birds agree in having a heart consisting of two pairs of chambers, a venous auricle and ventricle, and an arterial auricle and ventricle. The Eustachian valve is often wanting in the Mammalia. It is wanting, for instance, in the lion, bear, and porcupine; while it is broad and muscular in the seal, and assumes a spiral direction along the upper walls of the right auricular sinus in the elephant.

It was at one time imagined that the aquatic MAMMALIA were distinguished from the terrestrial by the *foramen ovale* being open and forming a communication between the two auricles. This, however, is a mistake, at least in the adult animal; for neither in the otter, the seal, nor the porpoise or dolphin, did Cuvier find this aperture pervious; and it may be inferred, that when it is open, it is an anormal remain of the fetal structure. In the *ornithorhyncus*, also, according to Sir Everard Home, it is impervious. In the porcupine and elephant, in which there are two anterior *venæ cavæ*, the blood of the left anterior *cava*, which opens in the sinus near the aurico-ventricular aperture, is conveyed directly into the right ventricle.

The reptile heart, the first in the cold-blooded division, varies somewhat in the several tribes. In the first three, the CHELONIAD, SAURIAL, and OPHIDIAL, it consists of two auricles and one ventricle, divided in some instances into communicating chambers. In the Batrachoid family, on the contrary, it always consists of one auricle and one ventricle, the interior of which is unilocular or undivided. In several of the Turtle tribe, among the first family, the ventricle consists of a pulmonary chamber, in which the blood is more particularly directed to the pulmonary artery, and a general or aortic chamber, which is above, and from which the blood is conveyed into the aorta. In the crocodile the ventricle is divided into three chambers, communicating by several apertures. One is inferior and to the right, and communicates with the right auricle by a large aperture provided with two valves. On the left, and before, is the second chamber, receiving the orifice of the left descending aorta. Behind is an aperture leading into the smallest chamber of the three, situate at the middle of the base of the heart, and receiving the common trunk of the pulmonary arteries. The left chamber is above. In the OPHIDIAL or SERPENTINE family the ventricle is divided into two chambers, a superior and inferior, separated by an imperfect partition, which allows the two to communicate.

The heart of the finny tribes is as simple as that of the Ranine reptiles, which indeed constitutes the preparatory step in the descending scale of organic forms. It consists, as in these animals, of two chambers only, an auricle and ventricle. The former receives the blood from the body at large, and transmits it to the ventricle, which is almost in all cases unilocular. From this a single vessel conveys it, not to the body at large, but to the gills, from which it is again collected by several branchial veins.

Of the blood-vessels of the four vertebrated classes it is superfluous to speak in any detail.

The most remarkable circumstances are the minute subdivisions which in some classes the arteries undergo previous to final distribution. In the Ruminants, and several of the PACHYDERMATA, the branches of the carotid artery, instead of uniting by the communicating vessels, are subdivided into a great number of minute vessels, which form round the pituitary gland a communicating plexus, denominated by the ancients *Rete mirabile*.

In the slow lemur (*lemur tardigradus*) Sir A. Carlisle found the subclavian artery, after entering the axilla, divide into 23 arterial cylinders of equal size, and the iliac on the brim of the pelvis into at least 20 equal-sized tubes, which in both cases surrounded the principal artery, reduced to a small vessel, and, proceeding along the extremity, were distributed chiefly to the muscles. (*Phil. Trans.* 1800.) A similar arrangement, carried to a still greater extent, was found in the *Ai* or three-toed sloth, in which the axillary and iliac arteries were divided into about 60 or 65 cylindrical parallel tubes. In the slender lemur (*Lemur loris*) these vessels are subdivided into 4 or 5 only.

In Fishes in which the unilocular ventricle sends its blood to the gills only, the heart is pulmonary, and the arterial system is destitute of central impulsive organ. In the sturgeon, which is one of the best examples of the distribution of the arterial system in the finny tribes, the blood, which is distributed in the *branchiæ* by the large artery, is collected in numerous vessels, which may be regarded as analogous to the pulmonary veins of the warm-blooded classes, but which have thick *parietes* like arteries; and these uniting, form a large vessel, which is lodged in a cartilaginous canal formed by the continuous bodies of the *vertebræ*. This vessel is further void of compressive or elastic tunics, and the blood moves through it as through an immovable and inelastic tube. From its sides, however, a series of arterial vessels issue, which forthwith assume the usual characters of arterial tubes. In many other fishes the *parietes* of the large artery adhere in part to the semi-osseous canal in which it is lodged.

SECT. II.—THE ORGANS OF AERATING CIRCULATION.

The lungs of the MAMMALIA are in all essential points perfectly similar to those of the human subject.

The lungs of Birds differ chiefly in not presenting distinct lobules, in having the air-vessels larger and more distinct, in the branchial tubes not becoming quite so small, and in terminating not alone in the pulmonic vesicles, but in perforated parts of the surface of the lungs, which lead into large air-sacs, communicating with all parts of the body, and forming an accessory lung. In the ostrich, which may be taken as a general example, there are four of these cells or aerolabous sacs. The first, which is anterior, extends from the *apex* of the chest to the iliac bones, between the first ribs and heart above, and between the lower ribs and a cell which surrounds the intestines. It is divided into four chambers, the first two communicating with the lungs by large apertures, while the fourth opens in the iliac bones. Behind this large sac are two small ones, between the iliac bones and the peritoneal sac. Before it is another small one occupying the lateral regions of the *apex* of the chest, and communicating with sacs in the *axillæ* and neck. Besides these, the stomach, liver, heart, and intestines are surrounded by sacs. All of these communicate by saccular processes with the cavities of the bones. By this peculiar arrangement BIRDS possess the greatest extent of respiratory surface of all classes of animals.

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The lungs of Reptiles are distinguished by consisting of large sacs, subdivided by membranous partitions into polygonal cells, which again are subdivided by smaller slips into smaller cells. In these cells the bronchial tubes are not ramified, but divide abruptly in them at the surface of the lung. Some idea of this arrangement may be obtained from the lung of the ordinary land-tortoise (*Testudo Græca*, Plate XXXVII. fig. 1). The sacs or large cells are smaller and more numerous in the turtle (fig. 2); but the general disposition is much the same.

Temporary gills of the tadpole.

The young of the Batrachoid family, and several of the water-lizard tribe, are provided with fimbriated or ciliated processes attached to the neck, and which are in all respects similar to the gills of fishes. These gills disappear as the animal grows; and when it assumes the true ranine or reptile character, vesicular lungs like those of other reptiles, and which had continued in a hitherto latent and rudimental state, are developed, and the animal breathes as others of the same tribe.

A peculiar form of respiratory organ is found in the lamprey or seven eyes, and the two species of hag-fish, (*Myxine*, Lin.; *Gastrobranchus*, Bl.; and *Gastrobranchus Dombey*). The former has on each side seven apertures leading into cylindrical tubes, in which the branchiæ are contained. (Plate XXXVII. fig. 3.) In the two species of hag these tubes are dilated into ovoidal cavities, in which the water is received, and on the membrane of which the branchial vessels are distributed. In this respect, therefore, the hag-fish approaches to the mode of respiration among the cephalopodous MOLLUSCA, in which the *branchiæ* are inclosed in a cavity. Lastly, in the *Aphrodite aculeata*, which may be taken as an example of the respiration of worms, there is a series of tubes like *tracheæ* and *bronchi*, proceeding from the surface to the interior, and in which the water containing the air requisite for respiration is received. (Fig. 6.)

SECT. III.—SECRETORY ORGANS.

Urinary organs of the oviparous classes.

Under this head ought to be described the urinary organs of the four vertebrated classes. Those of the MAMMALIA agree in consisting of kidneys more or less lobulated, ureters or excretory tubes, a reservoir or urinary bladder, and a urethra opening on the same mucous surface with the organs of generation. In the three oviparous classes considerable changes are made. Though in Birds and Reptiles the glandular organs denominated kidneys are left in the shape of aggregated glands with the two excretory tubes, the bladder is withdrawn, and the ureters open in the *cloaca*. The only apparent exceptions are the ostrich and cassowary, in which the *cloaca* is so organized that it may serve as a bladder or temporary receptacle of the urinary secretion. In the Reptiles the presence of this organ is variable, being found in the CHELONIAD and BATRACHOID; and the iguana, tupinambis, chameleon, stellio, and dragon, among the SAURIAL tribe; but wanting in the crocodile, lizard, *agami*, gecko, and the whole OPHIDIAL tribe. In Fishes it is not less variable. While the ray and shark tribe are destitute of bladder, and the ureters terminate in a *cloaca*, this receptacle exists in the sea-devil, lump-fish, globe-fish, and others of the cartilaginous division.

Poison gland and fangs of serpents.

A peculiar secreting organ, deserving notice, is the poison gland of the poisonous serpents. It is a glandular body situate on each side above the upper jaw, behind and below the eyes, with a considerable cavity, which opens into a long excretory tube, lying along the outer surface of the upper jaw, and opening in the tubular tooth, represented at fig. 17 and 18; and which is movable in an articulation, and may be erected, as in fig. 18, or depressed, as in 16, at the will of the animal. The poisonous serpents are therefore distinguished from the innocuous by the presence of the erectile movable tubular fangs. Fig. 15 is the head of the innocuous, and 16 of the poisonous serpent.

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PART III.—REPRODUCTIVE ORGANS.

Under this head we mention only the nipple-bag (*marsupium mammillare*), or secondary uterus of the Marsupial animals (Plate XXXVII. fig. 7); the nipples (fig. 8); and the manner in which the fœtal animal, in a very imperfect and embryal form, becomes attached by the mouth to the nipples (fig. 10). The *Marsupium*, therefore, ought to be regarded, not as a mere pouch in which the young may take refuge after they are grown, but as a subsidiary *uterus*, combining the character of the *Mammæ* of the other orders.

The MAMMALIA are peculiar in possessing a *uterus*. In the other classes this organ is withdrawn, and the ovary (fig. 11) and oviduct alone are left. In the ovo-viviparous animals, as the ovo-viviparous shark, the oviduct (fig. 12) resembles that of the common fowl. In the lower classes the ova are hatched out of the body entirely.

In the space assigned to this article, it was impossible to treat fully of a subject so extensive as the structure of the animal world; and while the author has arranged its divisions in such a manner as to show in what order it may be most easily and advantageously studied, he has introduced only those topics which are most indispensable, and most require illustration. For more complete details, therefore, he refers the reader to the following works.

1. *Leçons d'Anatomie Comparée* de G. Cuvier, Membre de l'Institut National, &c.; recueillies et publiées sous ses yeux par C. Duméril, chef des Travaux Anatomiques, &c. Cinq tomes. Paris, tome i. 1799;—tome v. 1805. 2. Blumenbach's *Manual of Comparative Anatomy;* with additional Notes by William Lawrence, Esq. F. R. S. Second edition, revised and augmented by William Coulson. Lond. 1827, 8vo. The notes are derived chiefly from the work of Cuvier and the papers of Sir E. Home in the *Philosophical Transactions.* 3. Gore's Translation of *Carus's Introduction to the Comparative Anatomy of Animals.* Lond. 1827, 2 vols. 8vo. The arrangement of this work, in which the author examines the forms of organs as they ascend, from the lowest to the highest classes, diminishes its general interest. 4. *Lectures on Comparative Anatomy, in which are explained the Preparations in the Hunterian Museum.* By Sir Everard Home, Bart. Lond. 1823, 6 vols. 4to. This work consists of the papers read by the author at the Royal Society, and published in their Transactions. Though entitled, therefore, *Lectures on Comparative Anatomy,* it embraces a much more extensive field, and contains a great number of physiological and pathological papers. This renders it at once rather desultory and prolix. It contains, nevertheless, a great number of facts illustrative of peculiarities of structure in the animal world; and it is particularly valuable by the number of engravings with which it is embellished. It can scarcely be said to possess any arrangement whatever. 5. *Recherches sur les Ossemens Fossiles, où l'on rétablit les caractères de plusieurs animaux dont les Révolutions du Globe ont détruit les espèces.* Par M. le Bar. G. Cuvier, &c. Nouvelle édition. Tome i. 1822, Osteology of the Elephant, Hippopotamus; tome ii. partie i. 1822, Osteology of the Rhinoceros, Horse, Hog, Daman, and Tapir; tome iv. 1823, Osteology of the Deer and Ox, the Bear, Hyena, Lion, Glutton, Wolf, and Dog; tome v. partie i. 1823, Osteology of the Reptiles, the Ichthyosaurus and the Plesiosaurus; partie ii. 1823, RODENTIA, EDENTATA, MONOTREMA, AMPHIBIA, and CETACEA. Paris, 1824. These papers contain much accurate osteological description.

(v.)

VEGETABLE ANATOMY.

Introductory Remarks.

All the plants which collectively form the vegetable kingdom have been arranged under two great divisions. Those which possess visible organs of reproduction, as stamens and pistils, have been termed *phænogamous*, and constitute the first 23 classes in the sexual system of Linnæus; while those in which the reproductive organs are either obscure or have not yet been discovered, have been termed *cryptogamous*, and form the 24th class of that system. Humboldt estimates the total number of known species at 44,000; of which 38,000 belong to the former division, and 6000 to the latter. M. Brogniart, jun. supposes the present known Flora to embrace 50,350 species, of which 10,200 may be considered as cryptogamous, and 40,150 species as belonging to the phænogamous division. On the present occasion we propose to describe the structure of those plants only which are included in the division of phænogamous plants.

Of the vast number of plants which cover the surface of our globe, it belongs to the botanist to describe the external forms in such manner as may serve to discriminate species, and assign to each its place in a methodical system of arrangement: it is the province of the anatomist to demonstrate, by dissection, their internal structure, so as to prepare the way for a rational explanation of their functions. In pursuing this object we may examine successively each of the parts as they severally present themselves to view; or we may, in the first place, study the elementary organs common to all plants, and then consider how their combinations form the different parts of vegetables. The former method is the *analytic*, and was necessarily that of the first observers; but, now that all the different parts are recognised as being formed out of the same elementary organs, we gain, both in conciseness and clearness, by adopting the latter or *synthetic* mode.

We shall accordingly describe, first, the elementary organs, and the primary textures which they form; and proceed afterwards to the consideration of the individual members and more complex organs of the plant. These elementary organs have been denominated vessels and cells; and they form, either singly or conjointly, what are called the vascular system and cellular tissue of plants. Their combination gives rise to certain textures, which appear in the well-known forms of skin, of bark, and of wood. On these we shall bestow the appellation of common textures, and exhibit a general view of their structure and disposition in the several parts of the vegetable body. A brief description of some minuter parts, as of hairs and glands, will terminate this division of the subject.

In the second part we shall begin with a description of the general structure of *seeds*, and afterwards treat more particularly of those bodies under the two great divisions of *monocotyledonous* and *dicotyledonous* seeds, tracing also the changes of form and of structure which they exhibit in their evolution and progress to the state of the mature plant. The structure of the *mature plant* itself will next claim our attention; and we shall accordingly exhibit the anatomy of its several members, as of the *trunk*, the *branch*, and the *root*, in their more remarkable varieties and forms. After this, the structure of the organs that spring from these several members, as *buds* and *bulbs*, *leaves*, *flowers*, and *fruits*, will be separately and distinctly examined; and having thus followed the progressive changes of form and of structure exhibited in the several stages of vegetable existence, we shall terminate our descriptions by anatomical representations of the organs in which the seed was produced, and the series of appearances successively displayed in its formation.

Through the whole of the descriptive detail we shall adhere as closely as we can to the language of demonstration; supporting and illustrating our representations of structure by continual reference to figures, selected in great part from authors of repute, and in some instances from dissections made by ourselves. We are aware, that of many reputed anatomical facts very different representations have been given, all equally professing to rest on microscopical observation. In such circumstances, we can do no more than report concisely the statements of different observers; but shall dwell chiefly on those descriptions and representations which seem best entitled to credit, and appear most conformable to the analogies of other organized structures.

When we consider the immense number of species that compose the vegetable kingdom, and call to mind that in form, in size, and in structure, each species differs from every other through every period of its existence, it must appear altogether impracticable to describe and delineate any considerable number. Fortunately, however, these diversities arise not from differences in the elementary organs, but chiefly from their varied proportion, disposition, and texture. In numerous species the disposition of the internal organs is very similar, where the external form and texture widely differ. In other instances the arrangement and composition of the internal parts vary not less than that of the external figure. Of these varieties we shall exhibit different examples.

In describing individual parts or organs, we might have brought many concurring examples, and exhibited many similar representations, to confirm the views of structure under consideration; but, in general, we have dwelt only on one or two examples, and these we have selected from plants which are either important in themselves, or whose structure has been most satisfactorily displayed, or which seemed to afford the best illustration of the peculiarities we were engaged in describing. From one example clearly given, the reader will readily apprehend the nature of analogous structures, and escape the perplexity and fatigue which unnecessary repetitions might occasion.

Instead, also, of describing the vegetable at one or two stationary points of its existence, in some of which its size is so minute as to be scarcely capable of demonstration, we have followed it through the several stages of its growth. In this way we really study it as a living body, continually exerting its vegetative powers, and daily exhibiting the most striking variations in external form, and frequently in internal structure. We hope thus to have conferred an interest on the descriptive part, which may in some measure relieve the unavoidable dryness of anatomical details; to have exhibited, in some instances, clearer views of vegetable organization; and to have given a continuity to the subject which isolated dissections, at a few stated periods, could not alone have bestowed.

It remains only to add a few remarks on the nomenclature employed in the present article.

In the description of external parts we have adhered chiefly to the Linnæan nomenclature; but some of the terms employed by Linnæus, in relation to anatomical structure, are exceedingly vague and inappropriate; others

Introductory Remarks.

are manifestly erroneous, and, however well suited to the purposes of botany, are not at all to be tolerated in any thing that aspires to correct anatomical description.

In the anatomy of seeds we have adopted many of the terms employed by Gærtner, in his excellent work *De Fructibus et Seminibus Plantarum*, most of which had previously been used by Malpighi and Grew.

Thus, in every instance, we have exercised our own judgment in the selection of terms, and, where it seemed necessary, have subjoined the synonyms of different writers. Though we presume not to say that we have uniformly chosen the best, we trust they will always clearly express the idea we designed to convey; and that, in general, they have been used in one and the same sense, and in no other. Except in one or two trivial instances, we have not ventured to introduce new terms, but have studiously sought to avoid it, retaining even an inappropriate expression, sanctioned by use, if it did not, at the same time, lead to ambiguity, or convey an idea evidently false; and we have in general resisted that torrent of new and barbarous terms, founded often on fancied refinements and pretended discoveries, with which several continental writers have of late attempted to deluge this branch of science.

Introductory Remarks.

PART I.

OF THE ANATOMY IN GENERAL OF THE ELEMENTARY ORGANS AND COMMON TEXTURES OF VEGETABLES.

CHAP. I.

OF THE ELEMENTARY ORGANS.

Preliminary observations.

Before we proceed to describe the structure of the individual parts of vegetables, it may be useful to exhibit a general view of the elementary organs of which they seem to be composed. Such a view will prepare the reader for understanding more clearly the descriptive language hereafter to be employed, and will even much abridge the extent to which that description must otherwise be carried.

Every one is familiar with the natural division of plants into herbs and trees, and is aware that, how different soever they may appear in form and texture, they all possess, in common, certain parts or members which we name the root, the trunk, and the branches, from which proceed the leaves, the flowers, the fruits, and seeds. Infinitely varied as these several parts are, in figure, size, and texture, they all originate from a few constituent or elementary organs, whose situation, proportions, and combination, give rise to all the diversity that we see. "Upon the anatomical analysis of all the parts of a plant," says Grew, "I have certainly found, that in all plants there are two, and only two, organical parts essentially distinct, viz. the pithy part and the ligneous part." (*Anatomy of Plants*, p. 19.) "And as every part hath two, so the whole vegetable, taken together," he adds, "is a composition of two only, and no more. All properly woody parts, strings, and fibres, are one body; all simple barks, piths, parenchymas, and pulps, and, as to their substantial nature, peels and skins, are all likewise but one body; the several parts of a vegetable differing from each other only by the various proportions and mixtures, and variated pores and structure, of these two bodies." (*Ibid.* p. 47.) In the anatomical descriptions of Malpighi, the compound structure is resolved, in like manner, into two constituent parts, called by him the ligneous and utricular portions. To these parts may be assigned the general appellations of the *Vascular System* and *Cellular Tissue* of plants, the description of which shall form the first subjects of consideration.

SECTION I.

Of the Vascular System.

ART. I.—*General Characters of the Vessels.*

Definition.

By the vascular system may be understood, in a general sense, all those parts of a plant which do not exhibit the form either of membrane or of cells. It constitutes almost the entire bulk of the more solid parts of trees, and by Grew and Malpighi was denominated the ligneous body, in contradistinction to the cellular tissue which accompanies it, and which forms by far the largest portion of many herbaceous plants. To common observation, a piece of dry wood appears to be a mass of solid fibres, that is, a series of particles arranged in a filiform figure, and destitute of any continuous canal. Thus Tournefort and others considered the ligneous parts of a plant to be a mass of minute solid filaments, placed parallel to each other, like the threads in a skein of silk, between the interstices of which the sap ascended; but the anatomical researches of Grew conducted him to a different conclusion. "If it be asked," says he, "what all that part of a plant, whether herb or tree, which is properly called the woody part—what all that is? I suppose that it is nothing else but a cluster of innumerable and most extraordinary small vessels or concave fibres." (*Anat. of Plants*, p. 20.) Malpighi held similar opinions concerning the vascularity of plants, which was farther attested by the microscopical observations of Hooke and Leeuwenhoeck. Du Hamel, though he admits that, under maceration, the parts of plants seem capable of indefinite subdivision, yet, from many circumstances, avows his conviction of their vascularity; and Hedwig maintains that the oldest and most compact plant is but a congeries of vessels and cells, which have nothing of the character of a fibrous solid, except in the thin membranous coats by which they are formed. (*De Fibræ Vegetab. Ortu*, p. 17.)

Names of the vessels.

Few circumstances have contributed more to perplex and retard our knowledge of the structure of plants, than the vague and erroneous nomenclature that has been employed to designate their constituent organs, more particularly in relation to the vascular system. Thus the several terms filaments, fibres, strings, threads, and nerves, which, in their ordinary acceptation, are understood to express a solid substance, have been constantly made use of in describing the tubes or vessels of plants. The same organs, however, even by the same writers, are frequently called tubular bodies, ligneous tubes, concave fibres, ducts, canals, arteries, veins, and vessels. In our future descriptions we shall employ the term vessel in a generic sense, to express all the diversity of names just enumerated; and the different kinds or species of vessels we shall hereafter attempt to discriminate by appropriate appellations.

Vessels, as we have said, exist in almost every part of a plant. In the higher orders of animals the fluids contained in the vessels are conveyed to a central reservoir called the heart, from which they are again sent out to all parts of the body. Near to this reservoir the ves-

Elementary Organs.

sels are few in number and large in size; and they gradually lessen in size and increase in number as they recede from it. In plants there is no such reservoir, but the fluids which enter by innumerable mouths at the root are at once distributed equally through all parts of the vegetable that are fitted to receive them. Hence in plants there is little variation in the diameter of the vessels; and their general figure is therefore cylindrical.

Their size.

From the extreme minuteness of the vessels, it is scarcely possible to compute their number with accuracy. By driving off their fluids without destroying their figure, as is done in the preparation of charcoal, Hooke numbered in a line, $\frac{1}{18}$th part of an inch long, not fewer than 150 vessels; therefore, in a line an inch long, there must be 2700, and in a surface of a square inch, 7,290,000 vessels; "which would seem incredible," says he, "were not every one left to believe his own eyes." These facts he verified by other observations on decayed wood, in which the vessels were empty; and also on petrifactions of ligneous bodies, in which the places of the vessels were very conspicuous. In very close and dense wood, as that of guaiacum, the vessels were still more minute than in the examples just quoted. (*Micrographia*, p. 101, 108.) In a piece of oak of the size of about $\frac{1}{19}$th part of a square inch, Leeuwenhoeck reckoned 20,000 vessels; so that in an oak-tree of no more than one foot in circumference, or about four inches in diameter, there will be found, according to his computation, 200,000,000 of such vessels. (*Select Works, translated by Hoole*, vol. i. p. 3.) The largest vessel observed by Hedwig (*De Vegetab. Ortu*, p. 26) in the stem of the gourd appeared through his microscope about $\frac{1}{12}$th of an inch in diameter; and as his instrument magnified 290 times, the true diameter must be reckoned the 3480th part of an inch, which would give for the square inch 12,110,400 vessels. In certain plants, however, the vessels are large enough to be discerned by the naked eye, and in some cases they acquire a large size.

From fasciculi.

The vessels of plants do not, like those of animals, exist single, but are collected into fasciculi or bundles, which, however, have often the appearance of single vessels. In the stems of herbs, and in roots, Grew discovered each small fasciculus to be composed of from 30 to 100, or sometimes many hundred vessels. (*Anatomy of Plants*, p. 20.) The direction of these fasciculi in the trunk is generally perpendicular, but in other parts their course is often oblique, and in their smaller ramifications they produce all sorts of figures. In herbs the fasciculi are more or less numerous, and placed often at considerable distances from each other, exhibiting the appearance of small columns dispersed through the cellular tissue: in other instances they are much more numerous, but destitute of any symmetrical arrangement; while, in trees, they are disposed regularly around the axis, presenting in their transverse section the well-known appearance of concentric circles in the wood.

Ramify.

In some parts, where the fasciculi stand at a distance from each other, some vessels often quit one parcel to unite with another, and return afterwards to that which they had previously left. In this manner they are said to ramify, and frequently, by their ramification, a reticulated appearance is produced, as occurs especially in the bark and leaves. In the wood of the trunk, where they stand collaterally in a perpendicular direction, they very seldom, if ever, run into one another, but keep, says Grew, like so many several vessels, all along distinct; as, by cutting, and so following any one fasciculus, may be observed. (*Anatomy of Plants*, p. 20.) In branches and roots, though the direction of the fasciculi be changed, they seem only to break into smaller parcels, and run side by side, never inosculating with each other, nor being ramified, so as to be successively propagated one from another, as in the vessels of animals. Neither, adds he, are they wound together like threads in a rope, but are only contiguous or simply tangent, like the several cords in the braces of a drum. (*Anatomy of Plants*, p. 66.) Even in the leaf, where the vessels seem to ramify out of greater into less, as in the arteries of animals, yet, if the skin and pulp of the leaf be removed, and the vessels laid bare, it will appear that they are all of the same size everywhere in the leaf, and all continued through it, as distinct tubes, like the several threads in a skein of silk. The distribution of the vessels is not effected, therefore, by their ramifying out of greater into less, but by the division of a greater fasciculus into several smaller fasciculi, till at last they come to be single. (*Anatomy of Plants*, p. 155.)

Do not anastomose.

It may be doubted whether, when the vessels of different fasciculi come into contact, they ever actually unite and are lost in each other, forming that kind of connection which is called inosculation or anastomosis. Grew strenuously contends against any such connection of the vessels in any part of the plant. "On a superficial view, indeed, the vessels of the leaf," says he, "seem to be inosculated, not only side to side, but the ends of some into the sides of others: but neither is this ever really done, the lesser fasciculi being only so far diducted as to stand at right angles with the greater; but they are never inosculated, except end to end, or mouth to mouth, after they are come at last to their final distribution." (*Anatomy of Plants*, p. 155.) Malpighi, however, from the fact of the alternate separation and conjunction of the vessels, and from analogy with what occurs in the animal system, speaks always of the anastomosis of the vessels, but he nowhere gives us any thing like proof of the fact; and Du Hamel, from actual dissection of several fasciculi, regards them in their union as resembling more the nerves than the blood-vessels of animals. When, indeed, we consider the extraordinary minuteness of the vessels, and the circumstance of their possessing nearly the same size in every part, there is no room for that continual ramification out of one into another, and consequent diminution of diameter, that occur in the vessels of animals; and the immensity of their number, together with the endless separations and re-unions which their fasciculi make, seems calculated to fulfil the purposes of less general distribution in the plant, which successive division and perpetual anastomosis effect in the animal system.

Have no valves.

Another general circumstance in the vessels of plants is, that we do not discover in them any structure which has the true nature and use of valves, similar to what is met with in the veins and absorbent vessels of animals. Dr Hooke could never observe in their canal any thing that had the appearance of valves. (*Micrographia*, p. 116.) Did such a structure exist, the absorption of nutrient matter from the lobes of the seed, and its conveyance, in a backward course, to the embryo, could not, says Grew, have place; neither could the root, as it often does, grow upward and downward both at once. (*Anatomy of Plants.*) If the piece of a root of elm-tree be cut in autumn, the juices, says Du Hamel, are found to escape indifferently at either end, as the one or the other is alternately held downward; a circumstance, he observes, inconsistent with the opinion of Mariotte, who maintained the existence of valves. (*Phys. des Arbres*, tom. i. p. 56.) It is well known, also, that many plants may be made to grow in an inverted position, so as to put forth leaves and flowers from their roots; and large trees have been

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nourished by juices received through the extremities of their ingrafted branches, after all connection between the earth and the roots had been cut off. In general, indeed, the extreme minuteness of the vessels seems almost to preclude the possible existence of valves in their canal; but in some instances, where the vessels in aged trees have become enlarged, membranous productions have been found to occupy their cavities, which some have alleged to perform the office of valves. They occur, however, only at an advanced period of growth, and form no necessary part of the structure of the vessel, and, instead of promoting, contribute only to obstruct the course of the fluids.

Thus far with regard to the general nature of the vessels of plants: let us next discriminate their several species or kinds.

Art. II.—*Of the Common Sap-Vessels.*

Sap-vessels.

To ascertain the kinds and situation of the vessels of plants, various means have been employed. The plant has been dissected both in its dry and recent state; the natural qualities and movements of its fluids have been observed; and its vessels have been filled with coloured liquors, by causing it to vegetate in them. By the combined use of these several means, many important particulars have been ascertained; but it must be acknowledged that the question is still beset with doubts and difficulties, and that, with relation to it, great diversity of opinion continues to prevail. A concise statement of the facts ascertained with respect to the movements of the vegetable fluids may perhaps contribute to define the situation and kinds of the vessels that convey them.

Course of the sap.

It has been proved that, early in spring, before the leaves appear, a watery fluid rises abundantly in the woody part of the trunk of trees, and continues visibly to ascend to the very extremity of the branches, until the leaves are developed, when, to appearance, it ceases to flow, and can no longer be collected by perforating or tapping the tree. This fluid has been shown to ascend through the wood, and to rise, in general, most abundantly through its youngest or outmost circle; but in trees whose vessels have not been obstructed from age or other causes, it rises through every circle to the very pith, and, as far as can be judged, in all the vessels that compose those circles. At this early period of vegetation no fluid is found in the bark, nor between it and the wood, nor in the pith; but the vessels of the bark are perfectly dry. These facts are deducible from observations on the natural flow of the fluids by Grew, Du Hamel, Walker, and others; and are supported by various experiments of M. de la Baisse, Bonnet, Reichel, and others, made by causing plants and parts of plants to grow in coloured liquors, in which the vessels of the wood alone became filled; but no tinge of colour was communicated to those of the bark. To these vessels the several names of lymph-ducts, sap-vessels, ligneous tubes, ascending and adducent vessels, have been applied: we shall in future denominate them *sap-vessels.*

Kinds of sap-vessels.

The vessels which thus form the mass of wood have by some writers been distributed into different kinds, and supposed to exercise very different functions. At certain periods of vegetation they appear empty; and hence Malpighi supposed two species of vessels to exist in the wood, one destined to carry sap, and the other to convey air: to these latter, from their supposed office, he gave the name of *tracheæ*, and from their structure called them spiral vessels. (*Anatom. Plantar. Idea*, p. 3.) Grew also believed these empty tubes to be air-vessels, but admitted that at certain seasons they carried sap. At an early period, however, Ray maintained that the vessels thus supposed to convey air were truly sap-vessels; and Du Hamel, in common with Grew, admitted that they carried sap in spring. Hill considered them altogether as sap-vessels; and Reichel, Hedwig, and others, by filling them with coloured fluids, proved that such was their true office. On the other hand, no experiments, says Ludwig, have yet shown that there exist in vegetables vessels destined to convey only air; and in this opinion subsequent writers, with few exceptions, have acquiesced. It will, however, be convenient to treat of their general nature and form under the distinct appellations of *sap-vessels* and *spiral vessels*, by which they are commonly known.

Opinion of Grew.

By Grew and Malpighi the common sap-vessels were regarded as entire tubes, having no apertures but in the direction of their length. Grew represents a single vessel as having the appearance exhibited in fig. 1, Plate XXXVIII., the aperture or canal of which is not visible unless highly magnified, as in fig. 2.

Of Malpighi.

According to Malpighi these vessels send off numerous capillary filaments to the cellular tissue, so that the cells are surrounded by a plexus of vessels, as is particularly seen in the pith of elder and some others; and these ramifications, he adds, spring probably from the perpendicular vessels both in the bark and wood. (*Anatom. Plantar.* p. 29. Lugd. Bat. 1688.)

Of Leeuwenhoeck.

These lateral ramifications were observed also by Leeuwenhoeck in a piece of fir-wood newly felled. Of this wood he procured a longitudinal section, so extremely thin that he could see distinctly the particles of fluid moving in the vessels, as represented in the upper portion of fig. 3, Plate XXXVIII.; while lower down, on many parts of these vessels, small points or dots were visible, which he at length discovered to be round apertures; and as he did not see these apertures in any other parts than those in which he had separated the horizontal cellular tissue from the perpendicular vessels, he concluded that, at these points, these two organs were connected. He farther separated two of the vessels from the remainder, and through the microscope they appeared as in fig. 4; but the "engraver," he adds, "said that he could not possibly draw all the jagged parts that he saw; and we both of us perceived, in the broken membrane or coat of the tube, many excessively minute vessels, which, by reason of their smallness, he was unable to express in the drawing." (*Select Works of Leeuwenhoeck*, by Hoole, vol. i. p. 12.)

It may however be said, that this communication between the vessels and cells is maintained not by ramifications from the vessels, but through apertures or pores in their sides; and, accordingly, many appearances have been remarked as existing on the sides of the vessels, of which different authors have given very different representations, and which some have regarded as pores. Thus, on the vessels of the fir Malpighi observed certain dotted appearances, which he describes as roundish tubercles, and which were so numerous that they appeared to cover the vessels. On the vessels of the elm, the beech, and the willow, Leeuwenhoeck saw similar particles, which resembled small globules. (*Select Works*, vol. ii. p. 1.)

Of Hill.

Dr Hill describes the vessels of the alburnum, or newly formed wood of the willow, as connected with each other by a flocculent interstitial matter. When, by long maceration, this matter is detached, the vessels then exhibit a dotted appearance; and, if examined by a highly magnifying power, these dots, according to him, are so many oval swellings, and each has, as it were, a mouth. Through these mouths, which he represents as innumerable, and

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existing on all parts of the vessels, he conceives the fluids to be discharged into the cellular tissue. (*On the Construction of Timber*, p. 18.) In fig. 5, Plate XXXVIII., is a representation of these vessels connected by flocculent matter, with their extremities collapsed from the escape of their juices, and their sides sprinkled with the little mouths which he mentions. These mouths, if they exist at all, are probably not pores in the sides of the vessels, but the little apertures seen by Leeuwenhoeck, and produced by the separation of the cellular tissue while the parts are still young and tender. The same author, speaking of the vessels of the mature wood of the pear, states them to be close canals, as in fig. 6, with no lateral apertures in them.

Opinion of Mirbel.

A still later writer, M. Mirbel, declares, that not fewer than five species of vessels are to be found in the woody part of plants. These he denominates porous tubes, cleft tubes, tracheæ, mixed tubes, and vessels *en chapelet*, from their supposed resemblance to a string of beads. Of these several species we have given representations in figures 7, 8, 9, 10, 11, and 12, Plate XXXVIII. The first species, or porous tubes, according to this writer, exist in every part of the plant where the sap moves with freedom. Their sides are covered with small eminences or projections, in the centre of which is to be found a small pore. (*Exposition de la Théorie de l' Organisation Végétale*, p. 107.) Improving a little on Hill, he represents these pores not as promiscuously placed, but as ranged in transverse lines (fig. 7); and through them he conceives the fluids of the plant to percolate, not, however, into the cells only, but out of one layer of tubes into another, in a lateral direction. In this manner he conducts the fluids from the centre to the circumference of the wood, and at length, by a route not so easily followed, contrives to get them into the vessels of the bark, the sides of which he declares to be perfectly entire, and alike destitute of pores and clefts. (*Ibid.* p. 297.)

Of Kieser and others.

Several writers have sought to discover these alleged pores in the sides of the vessels. With Malpighi, some regard the appearances observed not as pores, but as elevations on the surface of the vessels; others, as particles contained within them. Under a very highly magnifying power, Kieser thinks he has, in some vessels, detected the existence of pores; while M. Dutrochet pronounces the same objects to be corpuscles, filled with nervous matter; and De Candolle suggests the probability of their being small glands, destined in some way to contribute to the nutrition of the plant. These different opinions, formed on viewing the same objects, sufficiently manifest the difficulty and uncertainty of microscopical observations made with highly magnifying powers, as was long since pointed out by Hooke, who first applied the microscope to the examination of the structure of plants. "Of such minute objects," says he, "there is much more difficulty to discover the true shape by an instrument than by the naked eye; the same object quite differing in one position to the light, from what it really is and may be shown to be in another. In some objects," he adds, "it is exceedingly difficult to distinguish between a prominency and a depression, between a shadow and a black stain, or a reflection and a whiteness in the colour; and the transparency of most objects renders them yet more difficult than if they were opaque." (*Micrographia*, Preface.)

Art. III.—*Of the Spiral Vessels.*

Description.

Various as have been the opinions of writers respecting the *common* sap-vessels of plants, they have differed yet more in their views concerning the position, number, size, structure, and uses of those which have been denominated *spiral*. The common fathers of Vegetable Anatomy, Grew and Malpighi, who at the same time, but in different countries, prosecuted their inquiries without any knowledge of or communication with each other, are nearly of one opinion on all the more important points in relation to these vessels. Later writers have differed alike from them, and from each other, on almost every point. As the subject is of fundamental importance in the economy of vegetables, we shall endeavour to set before the reader the leading facts and opinions concerning it; to canvass their relative merits; and deduce from the whole such conclusions as seem most nearly to approach the truth.

Opinion of Malpighi.

Malpighi describes spiral vessels as existing in the ligneous parts of all plants. He called them *spiral tubes*, because, when extended, they were resolved, not into separate rings, but into a single zone, which might be drawn out to a great length. In general they form continuous tubes, but are sometimes contracted at regular distances, so as to resemble somewhat a series of oblong cells. One of these contracted spiral vessels, as delineated by Malpighi, is represented in fig. 17, Plate XXXVIII., at the extremity of which the spiral filament is in part drawn out; and similar appearances of the spiral structure are exhibited in figures 9 and 10, by Mirbel. In herbs, according to Malpighi, these spiral vessels constantly accompany the common sap-vessels, and are ensheathed by them; in shrubs, they occur in every part of the wood, single or in clusters; and in trees, an intermixture of spiral vessels with the common sap-vessels is observed in every part of the wood. In the fir, they are found immediately beneath the bark, and are so numerous as to constitute the chief bulk of the wood. They exist with the sap-vessels in the petioles and ribs of the leaf, and likewise in the petals of the flower. In the roots they are also met with, and in some roots are so abundant, as to exceed in bulk all the other parts. They exist, he adds, in every part of the plant except the bark; and are annually formed with the alburnous vessels of trees. (*Anatom. Plantar. passim.*)

Of Grew.

From the writings of Grew we collect also that spiral vessels exist in every part of a plant except the bark. In the root they are numerous, of very various size, and their bore is generally larger than that of the common sap-vessels. In the trunks both of herbs and trees they are equally visible, and in position, size, and number, subject to great variation. Sometimes they are collected into fasciculi, at other times they are disposed in rays, and in other instances they are arranged in a circular form: they stand sometimes next to the pith, in other instances next to the bark, and in other cases again they alternate with the common sap-vessels in every part of the wood. They have a more ample bore than the common vessels, and vary in size to at least twenty different degrees. In the leaf they always accompany the sap-vessels, and both in its petiole and ribs are constantly surrounded or ensheathed by them. They have a similar position in the petals of the flower, and in the vascular parts of the fruit. (*Anatomy of Plants, passim.*) Hence, then, it appears, from the dissections of Malpighi and Grew, that, in every plant in which vessels are to be seen, and almost in every part of it, spiral vessels abound; they exist, however, only in the *ligneous portion*, or that part in which the sap *ascends*, and are never to be found in the bark.

Of Du Hamel.

By Du Hamel, the spiral vessels, supposed to convey air, are described as existing in the leaves and the flowers, the petals of which are almost wholly composed of them. In the herbaceous portion of young branches

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they are also well seen; which portion afterwards becomes ligneous; so that it cannot be doubted that they exist in the wood, though he could never discover them but in young branches. (*Phys. des Arbres*, tom. i. p. 42.) If, however, all the empty vessels seen in a transverse section of the wood be deemed air-vessels, and all air-vessels have a spiral structure, then, says this author, they would, in many plants, form a great part of the ligneous body. From these large vessels, however, he has seen, in autumn, fluids to escape; so that they are not properly air-vessels, or, as Grew observed, they sometimes carry sap. They are not to be found in the bark.

Opinion of Hill,

Under the common name of sap-vessels, Hill delineates all the varieties of vessels that constitute the wood; they are largest in the outer circles, smaller in the others; they contain, says he, in spring and at midsummer, a limpid liquor; but at all other seasons they appear empty, and have therefore been erroneously deemed air-vessels. He says nothing of their spiral construction; but describes the vessels which form the chief mass of the wood as possessing solid and firm coats, forming an arrangement of plain and simple tubes, as in fig. 6, Plate XXXVIII., resembling those of the alburnum, except that they have no mouths in their sides. (*On the Construction of Timber*, p. 8 and 19.)

of Reichel,

M. Reichel maintains the existence of spiral vessels in almost all parts of the plant. By causing plants to vegetate in coloured fluids, he traced them from the roots, through the trunk and branches, to the extremity of the leaves, and into all parts of the flower,—as the calyx, the petals, the style, the stamens, and the anthers. In fruits and in seeds, and in the radicle and plume of the latter, they were equally apparent. The coloured liquors, as they rose, communicated a tinge to the cellular tissue of the wood, as was previously observed by De la Baisse; but no trace of colour was ever observed either in the bark or pith, which therefore contain no spiral vessels. He considered the spiral vessels as the organs everywhere conveying nutrient matter to the plant, and as having no title to the appellation of air-vessels. (*Encyclop. Méthodique*, article *Physiol. Végét.* p. 288.) Similar experiments of Hedwig and others confirm these facts as to the general distribution of the spiral vessels, and their bearing to every part the fluids absorbed by the roots.

of Mirbel,

We have already enumerated the five different species of vessels which Mirbel regards as constituting the woody part of plants. According to him, true spiral vessels (which he continues to denominate *tracheæ*) are not to be found in the root, but only in the trunk and the parts which are produced from it. Even in the trunk they are to be found only around the pith, and never in the exterior ligneous layers. He admits that they exist in all soft and succulent parts, and that coloured fluids rise in them as well as in the other varieties of vessels; but they never are to be found either in the bark or pith. (*Exposition de la Théorie de l'Organisation Végétale*, p. 74, 78.)

of Kieser.

According to M. Kieser, spiral vessels are found in all the more perfect plants, from the earliest period of their existence; and in all parts of them, except the bark and pith. They vary much in size, and in aged plants are frequently obstructed by a species of vesicle, which originates from the interior sides of the vessels. According to him, nothing but air is found in their cavity, though, in the wood of guaiacum, he has seen all the spiral vessels, in common with the cellular tissue, completely filled with resinous matter. He does not know the anatomical relation subsisting between the spiral vessels and the other organs; but thinks it proved that no direct communication exists between them and the cells. (*Mém. sur l'Organisation des Plantes*, 1814, p. 116, 117.) Lastly, M. de Candolle admits the existence of spiral vessels in the wood of the trunk, but not of the roots; and, with Kieser, regards them as conveying only air. (*Organographie Végétale*, tome i. p. 39.)

From the combined observations of all the preceding writers, with the exception of MM. Mirbel and de Candolle, we learn that spiral vessels exist not only in every part of the trunk, but in the root, and in every other part of the plant except the bark and the pith. From the actual presence of sap in these vessels early in spring, and again in autumn, and from the entrance of coloured fluids at all seasons, we also learn, that their true office is not to convey air, as Malpighi and others formerly, and Kieser and others more recently, maintain; but to carry sap. Are we therefore to regard them as a species distinct from the common sap-vessels, or are both to be held merely as varieties of one common kind? This question may receive some illustration from a little farther inquiry into the formation and structure of the sap and spiral vessels.

Art. IV.—*Of the Structure of the Sap and Spiral Vessels.*

Structure of sap-vessels.

Malpighi seems to have regarded the common sap-vessels as being formed of a series of small vesicles or cells, mutually opening into each other. (*Anat. Plantar.* p. 28.) In this instance he appears either to have mistaken a series of elongated cells for vessels, or to have conceived that the contractions, occasionally formed in the vessels themselves, afforded evidence of their having been constructed originally by cells. Grew, on the other hand, considered these vessels to be composed of straight fibres, placed parallel to each other, so as to form a cylindrical tube. (*Anat. of Plants*, p. 112.) Leeuwenhoeck held them to be composed of two fine transparent coats, formed of other vessels excessively minute. (*Select Works*, vol. i. p. 11.) And Du Hamel, by submitting thin layers of wood to long maceration, obtained bundles of longitudinal fibres of extreme minuteness, by which he considered the lymphatic vessels of the wood to be formed. (*Phys. des Arbres*, tome i. p. 32.) Hill describes the alburnous vessels as being formed of the same material as the cells, and to collapse when emptied of their fluids. In one instance, where a strong light was made to penetrate the vessel, it appeared as if composed of numerous cells; but on farther examination, these seeming divisions altered their places, and were found to proceed from portions of watery sap still retained in the vessel. This appearance, as he properly observes, may be a very necessary lesson against hasty judgments. (*Construction of Timber*, p. 33.)

According to M. Mirbel, "the entire mass of the plant is nothing but cellular tissue, the cells of which differ only in form and dimensions." The cells and vessels are thus considered to be formed out of one and the same membranous tissue. In forming cells, this membrane is supposed to dilate in every direction: in producing vessels, it increases only in length. (*Exposition de la Théorie de l'Organisation Végétale.*) The manner in which he supposes the vessels to be formed out of the primitive membrane is very fanciful; and he is probably right in thinking that "no one before himself had formed a similar conception of vegetable organization."

Structure of spiral vessels.

Concerning the structure of the *spiral* vessels, opinions have varied still more than in relation to those just considered. Malpighi describes them as composed of

a thin pellucid plate, of a silvery colour, somewhat broad, and which, being placed spirally, and united at its edges, constructs a tube. When this tube is drawn out, it does not separate into distinct rings, but is resolved into a continuous spiral zone. At particular places these vessels are sometimes contracted, so as to exhibit the appearance of oblong cells opening into each other, as in fig. 17, Plate XXXVIII. In size they greatly surpass the ordinary sap-vessels; and their canal is then frequently occupied by membranous vesicles, which nearly fill their cavity. (*Anat. Plantar.* p. 3–26.) These vesicles were also observed by Leeuwenhoeck, and their appearance, in the transverse section of an enlarged vessel, is represented in fig. 25.

Opinion of Malpighi,

Grew,

According to Grew, the thin plate that forms the spiral vessel is not flat, and, instead of being single, consists of two or more round filaments or threads, placed collaterally, but perfectly distinct. These component filaments he regards as united by other smaller transverse filaments, and the thin plates which they form by their connection constitute the spiral vessel,—" as if we should imagine," he adds, " a piece of fine narrow riband to be wound spirally, and edge to edge, round a stick, and the stick being drawn out, the riband to be left in the figure of a tube, answerable to a spiral vessel." As, however, the riband is composed of numerous threads, placed parallel to each other, so is the plate that forms the spiral vessel; and it is according to the greater or less delicacy of the vessel examined, and the manner of its dissection, that it appears to be constituted either of a flat plate or a round filament. The spiration of the filaments he considered to be made in the root from right to left, and in the trunk from left to right. (*Anat. of Plants*, p. 73 and 117.)

Du Hamel, Hedwig,

The opinion of Du Hamel with respect to the construction of these vessels was very similar to that of Grew, and he employed the same analogy of a riband twisted round a stick to illustrate it. Hedwig gave a very different account of them. He considered the spiral vessel to be composed of two distinct parts; one a membranous canal conveying air, and the other a spiral tube rolled round it, by which the fluids were conveyed. The spires of the tube, in some instances, are represented as close; in others they are separated, and the intervening portions of the membranous canal exhibit a dotted appearance. He considered all the sap-vessels, from their first formation, to possess this compound structure, and, by a series of changes, which he professes to describe, to be ultimately transformed into the solid fibre of the wood. (*De Fibræ Vegetab. Ortu*, p. 25.) Others, also, have believed the spiral vessel to be formed of a membranous tube, but have denied that it conveyed air; and the spiral tube of Hedwig they have regarded as a solid filament. From the different appearances which they exhibit, MM. Treviranus and Bernhardi distinguish several varieties of spiral vessels; as does also M. Kieser, whose account of these vessels is not only the most elaborate, but that probably which approaches nearest to truth. We shall therefore subjoin a brief abstract of his observations on the structure of these vessels, and more particularly on the series of *transformations* which they seem to undergo.

Kieser.

The construction of these vessels M. Kieser professes to have studied with the greatest care, and to have established incontestably the following points. Sometimes, says he, only one fibre, sometimes many, go to form the spire of a vessel. These fibres are commonly round, sometimes a little flattened, and are twisted spirally about an empty space, so as to form a tube. The spiral fibres in young plants, and sometimes in mature ones, are in close contact; in other instances they are separated, and the interstices are then occupied by a dotted or punctuated membrane, as is very frequent in trees; or sometimes they are connected by ramifications which proceed from the spiral fibres themselves. From the minuteness of the spiral fibre, it is difficult to decide whether it is a solid or tubular body, and often, from the same cause, to pronounce whether it is round or flattened. It is transparent, has considerable consistence and tenacity, and in some plants appears to possess elasticity.

The number of fibres that form the spire of a vessel is very various; sometimes, as before remarked, there is only one, but more often several, which are twisted in the same plane and the same direction. He has seen nine fibres thus united; and when unrolled, the spires of the vessels then seem to form a kind of riband. When many fibres are employed to form a spire, they always run parallel, and do not cross; so that the side of the vessel has never more than the thickness of a single fibre. At their first formation the fibres are not united; it is only in more advanced age that they become united, either by ramifications from their edges, or by a peculiar membrane. The direction of the fibre in twisting is sometimes from right to left, and sometimes the contrary. The size also is very various. In young plants it is very small, so that a millimètre comprises the diameter of 2600 of these fibres; and in some instances they have little more than half that size. In older vessels they have a larger size. Between the knots of the trunk they are simple, and do not ramify; but in the knots they undergo great changes of form, and are variously ramified and combined.

Art. V.—*Of the Transformations of the Spiral Vessels.*

Opinion of Grew,

It was the opinion of Grew, that the " common sap-vessels begin to be formed in spring, but the spiral vessels not till the end of summer, at least not till about that time do they appear." (*Anat. of Plants*, p. 131.) Malpighi also describes these vessels as gradually appearing in the alburnum, and augmenting in size in every successive ring of wood; an observation made also by Grew, who describes the " spiral vessels as being amplified in each annual ring, so as to form a vessel of a wider bore." These facts indicate that the spiral vessels, after their formation, undergo considerable changes in the progress of vegetation, or, to use the language of Grew, that " they are postnate, and seem produced by some alteration in the quality, position, and texture of their fibres."

of Kieser.

In treating of the transformations or metamorphoses of the spiral vessels, M. Kieser illustrates his ideas by a series of dissections of the stem and root of the gourd (*cucurbita pepo*), made apparently with great care. These designs occupy several plates of his work; and being taken from different parts of the same plant, at different stages of its growth, and viewed with the same magnifying power, they show the progressive changes in form and appearance of these vessels as the plant increases in age. M. Kieser exhibits corresponding vertical and horizontal sections of the same parts; but our object will be answered by copying only certain portions of the vertical sections.

The ligneous portion of the stem of the gourd possesses ten bundles of vessels, symmetrically disposed around the pith, and standing at unequal distances between it and the bark. In fig. 13, Plate XXXVIII., we have copied the representation of a vertical section of the vessels in one of these bundles, taken from a portion of the plant near the summit of its stem, and made with the aid of a microscope magnifying 130 times. The number of vessels in each bundle at this period is said to vary from three to five. They are constructed of one or more fibres, placed

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contiguous to each other, and twisted into a spiral form, producing a round cavity within. These are called *simple* spirals. They are found in every young plant, and in the newly formed parts of old ones. Their size is smaller than that of the other varieties to which they give origin. The number of fibres in each spire varies from one to nine; and they are the only variety met with in some of the inferior vegetables.

Simple spiral.

The next figure (fig. 14, Plate XXXVIII.) exhibits a similar section of the vessels of the same plant at the internodial space below. Of the four vessels contained in this bundle, the outer one, *a*, is larger than the rest, but its spires are contiguous, as in those of the former figure: the inner one, *i*, is formed of a series of rings, disposed in a perpendicular line. These rings are very like the spires of the preceding variety, and often combined with them in the same vessel. They are sometimes separated from each other only by a space equal to their own diameter; in other instances to eight or ten times that distance, forming then the substratum of the next variety. In their present form they constitute the *annular* spiral; and in herbaceous plants occupy frequently the same position as the simple spiral, that is, next to the pith.

Annular spiral.

From the two simple varieties of form just described, other more complex forms are produced, as the plant advances in age. In the next section, made still lower down on the same plant, the vessels exhibit the forms represented in fig. 15 of the same plate, which brings the third variety of spiral vessel into view. The exterior vessel, *b*, of this fasciculus, or that nearest to the bark, is of much larger size: its spires, represented by the white lines in the figure, are separated to nearly equal distances from each other, and the intervening spaces are filled up with a membrane, sprinkled over with small obscure points or dots, constituting the *punctuated* spiral vessel. In this variety the rings are never contiguous. Such vessels occur only in the more advanced age of herbaceous plants, but are said to be original formations in the alburnum of trees: they acquire a much greater size than the two former varieties, especially in the stem; but do not become so large in the root. In herbs they occupy a position exterior to that of the two preceding varieties; but in trees the largest vessels of the annual layers are nearer to the pith. The three other vessels in this figure are simple spirals, in part unrolled.

Punctuated spiral.

The spiral fibre in these vessels is of various size, being largest in the greatest vessels: it is sometimes so small as to be scarcely visible. It is often difficult to determine whether its form is spiral or annular: for the most part it is spiral in herbs, and annular in trees. The membrane which connects the spires or rings in this variety is not visible in young vessels, but appears in more mature age. It is at first transparent, but becomes opaque from age. In this punctuated variety of vessel the spires cannot be unrolled without tearing the connecting membrane. As to the points or dots observed on this membrane, they have been taken by some for pores on its surface; by others for clefts produced by the joining of the spires. They are clearly not clefts, says M. Kieser, and it is against the supposition of their being pores that their position has a relation always to the spires, and not to the adjoining cells. In the vessels of some plants, as in those of the French bean, when magnified 400 times, these points, fig. 21, *a*, seem as if pierced by a hole exceedingly small; but in other instances they are quite dark, and similar to those found on the membranous productions that fill the cavity of aged vessels, where there is not the smallest reason for considering them as pores. There seems a great analogy between these connecting membranes and those which thus fill the cavity of aged vessels. In some instances the size of the dots is large, and they appear transparent at the centre; in others the dots are extremely small. Their form is oblong, and they are ranged generally in determined lines, parallel to the direction of the spires.

In the next vertical section of a fasciculus of vessels, taken from about the middle of the stem of the same plant, all the peculiarities of size and form are still more distinctly seen. Of the twenty-three vessels which appeared in the horizontal section of a fasciculus at this period of growth, six only were apparent in the vertical section, and are exhibited together in fig. 16, Plate XXXVIII. Of these, the first two, or outer ones, are by much the largest, and belong to the punctuated variety. A portion of the anterior wall of these two vessels has been removed by the sections at *l*, *l*, so that the inner surface of the posterior wall is brought into view; and in the former vessel, *d*, a portion of the posterior wall itself has also been carried away. In both vessels the spiral fibre, indicated by the white line, is prominent in the section; and in the second, *e*, it is unrolled at *m*, *n*,—where, at *m*, it is seen single, transparent, and round, while at *n* it is united with the punctuated membrane that connects the spires, and has a flat or riband-like form. The third vessel, *f*, of this fasciculus is also of the punctuated class, and the three last, *g*, *h*, *i*, are simple spirals; the last of all, *i*, being in the progress of formation, and its spires not yet brought into a state of contiguity.

There is a fourth variety of vessel that is said to have the same origin as the last, being formed in part by spires or rings, but the separations between which are filled up, not by membrane, but by small productions or ramifications from the spires or rings themselves; and these ramifications are often so implicated as to form a net-work; whence the names of *ramified* and *reticulated* spiral vessels. Like the former variety, they do not exist in the young plant, but are formed gradually in a more mature age, and by the same series of actions; that is, the spires or rings, which were at first contiguous, separate at a later period, and the intervals are filled up by ramifications from the spires themselves. At first these ramifications are few, as in the vessel, *a*, fig. 21, when they are termed *ramified* spirals; and as these ramifications increase, the vessel becomes reticulated, as exhibited at the letter *c*, fig. 20. They are found but in few plants, and appear to differ from the punctuated variety chiefly in the position of the rings, which are more or less obliquely placed, and at different points send off one or more branches.

Ramified spiral.

Reticulated spiral.

In his ninth plate, M. Kieser has given similar representations of the vessels of the same plant, as they appear from sections made near the root. The fasciculus at this part of the stem contained twenty-nine vessels, as seen in the horizontal section, of which only eight were visible in the vertical section. These retained nearly the characters of those given in the preceding section, fig. 16; but exceeded them in number and size. The large ones, situated next the bark, were of the punctuated class, while the smaller ones, next the pith, were simple spirals. In fig. 18 we have copied the three smaller vessels. In one of these, *o*, which belongs to the punctuated variety, the interior of the vessel is nearly filled up with small portions of punctuated membrane, produced from the inner wall of the vessel itself, as is still more clearly seen in horizontal sections of similar vessels in fig. 25. The two vessels *p*, *q*, of fig. 18, are the youngest, and consist only of the simple spiral fibre; the last, it is said, being composed of two such fibres, which, in consequence of the transpa-

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rency of the posterior wall of the vessel, appear to cross each other.

Spirals of the root.

But M. Kieser has not confined his examination to the stem of this plant. In his tenth plate he has given similar sections of a portion of the root. The piece of root he examined presented, in the horizontal section, four fasciculi, each of which contained about thirty-seven vessels, varying in size; the larger ones being placed exteriorly, and the smaller ones towards the centre of the root. The cells of this part were small, and nearly of the same size and form throughout, differing much from the varying size and form of the cells in the stem. Of the thirty-seven vessels before mentioned, only ten were retained in the vertical section, all of which belonged to the punctuated variety. Of these, two had united so as to form but one cavity; and two others were filled up with membrane. In fig. 19 we have copied the appearance of three of these vessels. One of these, indicated by the letter *r*, is from the middle of the figure, and its size is intermediate between those on each side of it. A portion of its anterior wall has been carried away in three places, which brings the inner side of the posterior wall into view. The vessels *s t* of the same figure are the smallest, and situated at the centre of the root: all the three belong to the punctuated variety, no simple or annular spirals being found at this period in the root.

In the knots of plants the vessels undergo great changes of form, the larger vessels being contracted in different parts, and giving off productions or ramifications which form new vessels, and give to the whole a very irregular appearance, as may be seen in the upper part of fig. 20, taken from the appearance of the vessels in the knot of the balsam (*Impatiens Balsamina L.*). In this figure M. Kieser has also given an ideal representation of the various metamorphoses already described, viz. of the annular vessel into the simple spiral, and of that into the other varieties: thus the letter *a* represents the rings of the annular vessel, which at *b* begin to form the spiral: at *c* the simple spiral passes into the ramified variety, and this again, at *d*, into the reticulated vessel: at *e* the vessel becomes contracted at different parts, as previously observed by Malpighi, fig. 17, and by Mirbel, fig. 11 and 12. This latter author called this the

Vessels *en chapelet*.

vessel *en chapelet*, from its resemblance to a string of beads. From these vessels go off the branches *f f f*, to form the ramified spirals of the knot. In fig. 12 of the same plate M. Mirbel has given a similar ideal representation of the five *species* delineated by him in figs. 7, 8, 9, 10, and 11; but they do not carry with them the same evidence of accurate observation as the several *varieties* indicated in the alleged transformations of Kieser.

Such is the account given by M. Kieser, of the development and appearances of the vessels in herbaceous plants, and of the successive changes in character which, in the progress of growth, they undergo. All the figures except the last are taken from dissections of the same plant, beginning with that part of the stem which was of latest growth, and proceeding in succession to the parts of earlier growth, or older formation. At first the vessels are comparatively few in number, of nearly uniform size, and belong to the varieties of annular and simple spiral: at a later period those first formed become augmented in size, and assume the characters of punctuated and ramified vessels; they are now also removed farther from the centre, and their place is supplied by new vessels of simpler forms. With the age of the plant, they all continue to increase in size and number, and to acquire the new characters which distinguish the several varieties in the manner already described.

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In the early growth of trees, the formation and development of vessels go on at the centre, adjacent to the pith, in the same manner as in herbs; but at a later period, when the additional growth is made at the circumference of the tree, the first formation of vessels must occur in the alburnum, and the subsequent changes of character be effected in the several layers of wood; which accords with the fact that spiral vessels are rarely to be detected in the alburnum, but are found with all their different characters, and of all sizes, in the several layers of wood, as may be seen in all the transverse sections of wood delineated by Grew, Malpighi, and others. In truth, the descriptions of Kieser with respect to the structure and transformations of the spiral vessels accord, in most respects, with the opinions of Grew, as briefly stated, page 47 of this article, and as may be farther seen by referring to pages 73 and 177 of Grew's *Anatomy of Plants*.

It is further to be remarked that, in these representations of Kieser, which exhibit all the vessels visible in all parts of the stem and root of this plant, only *one kind* of vessel is described, which at different periods of growth assumes different forms; that no vessel answering to the common or lymphatic vessel of authors is mentioned; and consequently, that all the vessels described, however differing in size and external character, are in truth but varieties of one common kind. Calling to mind also that, in the earliest production of leaves and of flowers, and even of stamens and pistils, vessels either possessing the *spiral* character, or capable of assuming it, are everywhere met with,—that they occur also in the stem adjacent to the pith in succulent plants, and in the alburnum of trees, and every successive ring of wood produced from it—in short, in every part and portion of the plant, except the bark and pith,—and believing, as we do, in those changes of form suggested by Grew, and subsequently demonstrated by Kieser,—we are led to the general conclusion that

Only one kind of sap-vessel.

only *one kind* of vessel exists in the ligneous portion of other plants, as well as in that of the gourd; and that in different plants, and in different circumstances and conditions of vegetation, this vessel is capable of assuming the different forms, sizes, and characters, which have led many writers to describe these organs as constituting different species, and serving different uses.

Opinion of De Candolle.

M. de Candolle, in his late work on the Organography of Plants, seems also to reject the separate existence of the ordinary sap-vessels or lymph-ducts of authors, and to consider, with Kieser, all the vessels collectively to possess a spiral character, which appears under five different forms in the vessels severally named *tracheæ* or *simple* spirals, *annular* spirals, *punctuated* and *reticulated* spirals, and the vessels *en chapelet*. (*Organographie Végétale*, tome i. p. 32.) Without deciding positively in favour of Kieser's views, he admits that the different orders of vessels have among them very intimate relations; and in favour of the opinion that they are really modifications of each other, he alleges that almost all these orders exist together in certain classes of plants, and are wanting altogether in others. Still, though he has no theoretical objection to make to these alleged transitions of form, he has never been able to verify them by actual observation, and thinks the facts require further investigation. (*Ibid.* p. 48, 51.) With respect to the existence of pores in the spiral vessels, as alleged generally by Mirbel, and even occasionally by Kieser, but denied by a great number of observers, M. de Candolle has been led by his own observation to entertain doubts, and to believe that what has been regarded as a pore is a luminous point, such as is exhibited by bubbles of air in water, when placed under the microscope. (*Ibid.* p. 55.)

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Opinion of Dutrochet.

The late opinions of M. Dutrochet on the structure of plants seem to us to have drawn attention more from their novelty than their value. He criticises the opinions of Mirbel in relation to the structure of the vessels, and says that those denominated by that author *porous* tubes, are altogether destitute of pores, but have corpuscles adhering to, or rather implanted in their sides, on which account he calls them corpusculiferous tubes. (*Recherches Anatom. sur la Structure des Végétaux*, &c. p. 23.) In like manner the tracheæ are said to have similar corpuscles attached to their sides, but which adhere only weakly, and form no necessary part of the organization. (*Ibid.*) With respect to the uses of these two kinds of vessels in the wood, he considers the corpusculiferous tubes to be the canals by which the sap *ascends* from the roots; while the spiral vessels, or tracheæ, convey not air, but a diaphanous liquid, prepared in the leaves, and which descends, by the spiral vessels, to impart its vivifying influence to all parts of the plant. (*Ibid.* p. 29–31.) No direct communication, it is said, exists between the cells and vessels which compose the vegetable texture; they are only contiguous. Fluids, nevertheless, are transmitted from one to the other; not however through holes or passages expressly designed for that purpose, as Mirbel contends, but through intermolecular spaces, left between the integrant globular molecules, of which the organic solids are composed. (*Ibid.* p. 47, 48.)

Such is an outline of the different opinions that have been held regarding the *structure* of the sap-vessels. Differences not less great still continue to exist with regard to their *uses*. Our reasons have been already given for coinciding in opinion with those who hold the vessels to be the proper channels in which the sap is conveyed. M. Kieser, however, contends that the spiral vessels of the wood are always empty, or contain only air, and considers them, with Malpighi, to be organs by which air is conveyed. To this opinion M. de Candolle also inclines, though he admits that in some cases they may convey lymph. (*Organog. Végét.* tome i. p. 61.)

Those physiologists who thus oppose the opinion that the vessels carry fluids, suppose the sap to be conveyed by certain minute channels, said to exist between the cells. The place of these alleged channels is marked out in a section of cellular tissue (fig. 29, Plate XXXVIII.) taken from M. Kieser, in which the black points at the angular junctions of the cells are said to denote them: from their position they have obtained the name of *intercellular canals*. By many, however, the existence of such spaces at the angles of the cells is denied; and, indeed, when we contemplate the various size and form of the cells, the different degrees in which they are filled with fluid or solid matters, and consequently the greater or less degree of compression which these alleged intercellular spaces must undergo, we can hardly admit the sufficiency of such minute, tortuous, and precarious channels to convey the ascending sap with that force and velocity which the experiments of Hales and others have proved it to possess. On the other hand, no direct communication between the spiral vessels of plants and the external atmosphere, similar to that which occurs between the tracheæ of insects and the air, has been shown to exist; and the total absence of spiral vessels in the bark, where they would be near to the atmosphere, and their presence in the root, where they are almost beyond its influence, are alike repugnant to the notion that they exercise a respiratory function. Lastly, the absence of sap in these vessels at certain seasons, on which alone the notion of their being *tracheæ* or air-vessels was founded, depends, as we have seen, on the period at which the examination is made; for at certain periods they have been found filled with sap; and at all periods, when in active vegetation, they will absorb and convey coloured fluids. It should also be borne in mind that the respiratory function in vegetables is performed, not by the trunk, but by the leaves of the plant.

Intercellular canals.

Dismissing then these notions concerning the uses of the *spiral* vessels, and adhering to the opinion, that in all their variety they serve the office of conveying sap through the plant, we shall conclude this branch of the subject with a brief notice of their modes of *termination*.

Terminations of the vessels.

If we begin at the root, we may consider these vessels as terminating at that part, by continuation of canal, in the capillary *absorbents of the rootlet*. As, further, the vessels of plants, like those of animals, are the only organs which convey the materials out of which not only the fluid, but the solid parts of the plant are formed, it may, in a general sense, be said that their modes of termination are as numerous as the kinds of distinct parts or organs which the vegetable system contains. Hence, therefore, as the cellular tissue of plants contains various matters often precisely similar to those which exist in the vessels, it may be inferred that the vessels have a termination in those organs; and this inference may perhaps carry more weight with many than the attempts before related of Malpighi and Leeuwenhoeck to demonstrate it anatomically. Another termination of these vessels must be in certain minute and ill-defined organs called *glands*, which separate from the mass of fluids peculiar secretions; and a fourth mode may, in the leaves, be in other vessels which carry back the juices from those organs. The last and fifth mode of termination is into transpiring or exhalent organs, by which a certain portion of the contents of the vessels is discharged: so that in plants the sap-vessels terminate externally at one extremity in absorbents, by which fluids are received; and at the other in exhalents, by which these fluids are in part discharged.

Art. VI.—*Of the Proper Vessels.*

By observation of the natural flow of the sap, combined with the results of experiments made with coloured liquors, we have endeavoured to determine the situation and kinds of vessels by which it is conveyed in the wood. The same method will best assist us in ascertaining the nature and place of the vessels met with in the bark.

Course of the sap in the wood.

It was before stated, that, early in spring, the sap of plants rises through the wood alone, and that no fluid whatever is then to be found in the bark. At a later period, however, the case is completely reversed; for the vessels of the wood no longer appear to carry sap, and those of the bark then become abundantly supplied with it. This difference is very clearly and concisely stated by Grew. "The sap," says he, "in many plants, as the vine, ascends visibly through the wood for a month, in March and April, and rises through every ring of wood to the very centre, yet at the same time there ariseth no sap at all out of the bark, nor between it and the wood." "But late in spring," he continues, "and in summer, the sap is no longer visible in the wood, but is abundant in the bark, in the inner margin adjacent to the wood." Du Hamel, too, remarks, that when the lymph rises abundantly through the wood in spring, the bark is dry, and adheres to the wood, and no sap then issues from it, nor from between it and the wood; but, later in the season, he adds, the bark yields abundance of sap. These statements have been verified by the multiplied observations of various subsequent authors.

in the bark;

But why is the sap thus present only in the wood at its first rising in spring? Why at a later period does

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it cease to be visible in that part? And how and why does it afterwards find a passage into the bark? Some observations of Du Hamel, Hales, and Walker, point, we think, to the true cause. In spring, says Du Hamel, when the sap rises vigorously, the buds have not appeared; when they begin to open, the sap then flows less freely; and when the leaves are fully developed, then the flow of sap entirely ceases. Dr Hales also remarks, that, towards the end of April, when the young shoots come forth, and the surface of the vine is greatly increased by the expansion of the leaves, the sap then ceases to flow in a visible manner till the return of the next spring. All bleeding trees, he adds, cease to bleed as soon as the young leaves begin to expand enough to perspire plentifully, and draw off the redundant sap. The bark of oak, too, separates easily when lubricated with sap; but before the leaves appear and perspire, the bark will no longer run (as they term it), but adheres most firmly to the wood. (*Vegetable Statics*, 3d edit. p. 126.) In like manner, in an experiment of Dr Walker, a birch-tree bled from every perforation in its trunk, and from every cut extremity of its branches, until vernation or budding began; then the bleeding was almost immediately checked; and when the young leaves had pushed beyond the *hybernaculum*, the bleeding entirely ceased. (*Edin. Phil. Trans.* vol. i. p. 31.)

It is however certain, that though the sap was no longer visible in the wood after the leaves were developed, it continued nevertheless to rise through it; for in no other way could the leaves obtain the large portion of fluid which it is known that they constantly discharge by transpiration; and coloured fluids manifest their presence in the vessels of the wood, as well after as before the development of the leaves. The leaves, therefore, must be regarded as the organs which, by their perspiration, draw off, as Dr Hales observes, the redundant sap; and hence, in an experiment where a notch was cut two or three feet above the lower end of a stem, though a great quantity of sap passed by the notch, yet was it perfectly dry; because, says he, "the attraction of the perspiring leaves was greater than the force of trusion from the column of water." (*Vegetable Statics*, p. 111.)

Not only, however, does the development of the leaves render the sap no longer visible in the wood, but they also appear to be the organs by or through which it finds its way to the bark. In all the experiments just recited, the bark continued dry until the sap disappeared from the wood; in other words, until it was drawn off by the leaves; and then, and not till then, the bark became moist, and continued laden with sap through the rest of the summer. Now, as it has been before shown that no sap enters the bark by the roots, nor gets into it directly from the wood, there is no other known channel by which it can be conveyed, except through the leaves; and these, therefore, necessarily appear to be the organs by which it is apparently carried off from the wood, and by or through which it at the same time finds its way to the bark.

This inference appears to follow, not only from the fact of the bark continuing dry until the leaves are developed, but from the circumstance that it is again rendered dry after having become moist, if these same leaves be removed. If, says Du Hamel, we remove the leaves of a young tree when in full sap, and whose bark is easily detached, in a few days after the same bark will adhere as closely to the wood as it commonly does during winter. This direct connection between the leaves and bark is also well illustrated in an experiment of Hales, employed by him for a very different purpose. From two thriving shoots of a pear-tree he cut, in several places, half an inch of the bark off all round. All the ringlets of bark between these incisions had a leaf-bud upon them except one, and all but this one ringlet grew and swelled at their bottoms till August; and the larger and more thriving the leaf-bud was, so much the more did the adjoining bark swell. (*Veg. Statics*, p. 149.) Mr Knight also found the bark of the vine to become shrivelled and dry when the leaves were stripped off; but in those parts in which it communicated directly with the leaves, it continued moist and flourishing. (*Phil. Trans.* 1801, p. 335.)

By connecting, therefore, the circumstances attending the flow of sap with the development of the leaves, we gain satisfactory reasons for all the apparent anomalies observed to attend its course. Early in spring, before the appearance of the leaves, no natural outlet for the escape of the rising sap exists, and therefore, when the vessels are cut or perforated, they readily pour out their sap, or bleed; but late in spring, and in summer, when the leaves are developed, the more watery parts of the sap are thrown off by transpiration; and while this process proceeds, the fluids do not accumulate in such quantity in the minute vessels of the trunk as to be effused or bleed through their cut or perforated sides. A cold day, however, or a moist and still atmosphere, by checking transpiration from the leaves, restores more or less the propensity to bleeding from the trunk; and in autumn, when fructification begins, and vegetation makes a pause, the same disposition to bleeding recurs in the trunk, from the check imposed on the more active powers of growth.

Qualities of sap in the bark;

It is further evident, that, when the vessels of the bark become supplied with fluid, they cannot have derived it immediately from those of the wood, since, in these different parts, the fluids have frequently no sort of agreement in properties. Thus, Grew remarks, that almost all plants, late in spring, and in summer, bleed from their bark; and the sap has either a sour, sweet, hot, bitter, or other taste. At this period the bark of the vine yields a sour sap; but, "what is vulgarly called bleeding in the vine is," he adds, "quite another thing, both as to the liquor which issueth, and the place whence it issues; that is, it is neither a sweet nor a sour, but a tasteless sap, issuing, not from any vessels in the bark, but from the air-vessels of the wood." (*Anatomy of Plants*, p. 125.) Malpighi, also, was well aware of the difference in the qualities of the sap, and thought every plant possessed its peculiar sap; but he has not so accurately defined the situation of the vessels that contain it. Du Hamel, however, points out distinctly the difference of quality in the sap of the bark and wood. In the bark of some plants it is white, in others red, and in others yellow. It is in some instances milky, in others resinous, and in others gummy. In many plants it has a sweet taste, in some it is caustic, and in others insipid. It has sometimes much odour as well as flavour, and frequently it is destitute of both. (*Phys. des Arbres*, tome i. p. 68.)

acquired in the leaves.

But if the qualities of the sap in the bark be thus different from those of the sap in the wood; if these peculiar qualities are detected in it only after the development of the leaves, and the leaves be the organs by which alone the sap can be conveyed from the one part to the other; then it seems to follow that the sap must acquire these new properties in the leaves during its transmission through them. Malpighi remarked the existence of this altered sap in the leaves, and held them to be the organs which prepared nutrient matter for the plant; and Dr Darwin, by immersing plants of spurge in coloured liquors, not only saw, as others had previously done, the red fluid ascend through the leaf, but another fluid, of a

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white colour, returning at the same time from the extremities of the leaf, and descending into the petiole. (*Botanic Garden*, vol. i. notes, p. 450–53.) This same returning fluid Mr Knight observed in similar experiments on branches of the apple and horse-chesnut trees, and even traced it through the petiole into the inner bark, by the vessels of which it seemed to be conveyed to the extremities of the roots. (*Phil. Trans.* 1801.) The motion, therefore, of the sap in the bark is not that of *ascent*, as Grew and Malpighi and many others have believed, but of *descent*, as the observations and experiments of M. de Sarrabat, Du Hamel, Knight, and others, abundantly prove. To these vessels of the bark Grew assigned particular names, according to the apparent quality of the fluid they conveyed. Malpighi gave them the general appellation of *vasa peculiaria*, from their containing a fluid different from the common sap. By others they have been called *cortical vessels*, a term, however, not applicable to many tribes of vegetables which are entirely destitute of bark. Lastly, Du Hamel and others denominated them *proper vessels*, which term differs but slightly from the appellation of Malpighi, and, though not very precise, is that we shall continue to employ.

Description of the proper vessels;

From regarding the newly formed vessels of the wood as part of the bark, Grew uniformly represents the bark as possessing two distinct species of vessels, in which he has been since followed by several other writers; but the vessels which he calls *lymphæducts* belong rather to the wood, so that we may regard him as describing only one species of *proper vessels*. In herbs, these vessels stand sometimes in distinct parcels or columns; sometimes they are disposed in a ring; sometimes they have a radiated position; and sometimes they are more intermixed with the sap-vessels, and seem to alternate with them. In trees, the vessels of the bark are more distinct, and have a much more regular appearance. They are commonly postured near the inner margin of the bark, and, when viewed in a longitudinal direction, seem collected into fasciculi, which are more or less numerous, and the component vessels of which continually diverge and join with others, so as to form a reticulated appearance, as in fig. 24, Plate XXXVIII. Of these reticulated fasciculi, many layers exist in an old tree; and to these layers the thickness of the bark is chiefly owing. As they proceed inward, the direction of the fasciculi is less oblique, so that near to the wood they are almost straight. Hence the spaces formed by the reticulations are very unequal, often large in the exterior part of the bark, and diminishing in size towards the wood: they are everywhere filled with cellular tissue. Such is a general description of the situation of the *proper vessels* of the bark, as given by Grew, Malpighi, and Du Hamel.

their structure;

The vessels which thus form the vascular portion of the bark appear to differ but little in *structure* from the more simple vessels of the wood. Grew considered them to possess a similar structure, from believing them to be formed by the inner bark at the same time with the vessels of the wood; and therefore, he adds, "they may be reasonably thought similar in the bark and wood." (*Anat. of Plants*, p. 112.) Malpighi regarded them as simple tubes, containing sometimes peculiar juices; but advances nothing particular respecting their structure. (*Anat. Plantar.* p. 3.) M. Mirbel's opinion deserves some notice, inasmuch as he declares the structure of these vessels to differ entirely from all those of the wood. Their sides, says he, are perfectly entire; they have neither pores nor clefts, and may therefore be deemed simple tubes. (*Exposit. de la Théorie de l'Organisat. Végét.* p. 109.) A single vessel of this kind is represented in Plate XXXVIII. fig. 22; and in fig. 23 a fasciculus of the same vessels magnified is given as delineated by M. Mirbel. A remark also of Hill, if it be deemed to rest on correct observation, is entitled to great attention. "The vessels of the bark that form the fasciculi are not," says he, "united to each other, but are connected with the cellular tissue at numerous places; and, when separated from it, there appear on the sides of the vessels small oval depressions, dotted as it were with pin-holes." (*On the Construction of Timber*, p. 28.) These appearances he regards as of a glandular nature, but their description corresponds better with that of Leeuwenhoeck respecting the lateral ramifications from the vessels of the wood; and they may probably be the points at which communication is effected between the vessels and cells.

their reticulation;

The cause of the reticulated appearance which the vessels of the bark exhibit in trees, is doubtless to be attributed, as we think Du Hamel somewhere remarks, to their peculiar mode of growth. A new layer of cortical vessels is every year added to the inner surface of the bark, as well as a new layer of ligneous vessels to the outer surface of the wood; so that, as Grew observes, the new matter of the tree is every year distributed two contrary ways,—one part falling outward towards the bark, and the other part retaining its situation inward to constitute the wood. At first the newly formed cortical vessels are straight, and stand parallel, like those of the wood; but, by the continual growth of the new parts formed between the bark and the wood, the older vessels of the bark are gradually forced outward; and being thus every year disposed around a large cylinder, are necessarily more and more separated from each other, and produce at length that net-like form which we observe them to possess. The newly formed vessels of the wood, on the other hand, retain their original position, and therefore preserve their parallelism, seldom or never exhibiting those flexures and reticulations so common to the vessels of the bark.

their size;

In the bark, as well as in the wood, the vessels are found to possess different sizes. In the pine, vessels containing turpentine are represented by Grew, which are very much larger than the common sap-vessels, and are surrounded by smaller ones, exactly as the large spiral tubes of the wood are said to be ensheathed by the common sap-vessels. The milky juice of a species of sumach is contained in very large vessels, disposed so as to form a ring, and each large vessel is surrounded by many smaller ones. (*Anat. of Plants*, tab. 20.) The appearance of these large vessels in one species of pine is well represented by Hill, and the account he gives of their formation is probably correct. In this tree (*pinus orientalis*), some of these vessels form oval openings, large enough to admit a straw; these openings occupy the centre of the bark, and are surrounded by a ring of smaller vessels. As their contents are soluble in alcohol, it is easy to obtain them empty. In fig. 26, Plate XXXVIII., the vessels of this tree, as they appear in the bark, are displayed; the woody portion of the tree having been scooped away, so that the longitudinal aspect, as well as the transverse sections of them, is exhibited. From a strict inquiry into their nature, Dr Hill concluded that these larger vessels were originally the same as those of the smaller fasciculi in the bark of the same tree; "so that if we conceive one of these smaller fasciculi opened in its centre, and the vessels driven every way outward, till they are stopped by the substance of the bark, we shall have an idea of the structure of this large vessel, which is nothing more than a great cylindrical hollow formed in the centre of such a fasciculus." (Hill *on the Construction of Timber*,

Elementary Organs. p. 29.) It is in trees that have copious and viscid juices that these enlarged vessels are formed; and where the juices do not concrete, it is probable that, as the vessels annually recede from the centre, they suffer a reduction in size from the continued effects of desiccation and compression to which they are exposed.

Their position. The foregoing varieties appear alone entitled to the appellation of the *proper vessels* of the bark. In many tribes of vegetables, however, as will afterwards be shown, no distinction of bark and wood exists; but one uniform distribution of vessels extends from the centre to the circumference of the plant. Such plants have also their *proper vessels*, but the place and disposition of these vessels are not so precisely ascertained. From the mode in which their growth is accomplished, as well as from observation of their structure, it may be inferred that their *proper vessels* are distributed through the whole substance of the plant, accompanying in every part the sap-vessels. In some plants possessing this arrangement of parts, such as different species of wheat, Malpighi (*Anat. Plant.* tab. 4, fig. 15) describes and delineates a *vas proprium* as forming a part of each fasciculus of vessels; and a similar intermixture of the two kinds must, we conceive, exist in all similar structures.

Even in many plants possessing a distinct bark, vessels containing proper juices are found in the wood. In every circle of wood, from the inmost that surrounds the pith, to the outmost in contact with the bark, vessels containing a gum, turpentine, or some other concrete or coloured juice, may frequently be found. Malpighi conceived them to exist in all plants, though, from the nature of their fluids, they could not always be distinguished; and he believed them to afford a highly perfect juice for the nutrition of the plant. According to Grew, "the turpentine vessels that are scattered up and down the wood of the pine and fir are the self-same which did once appertain to the bark; but being pinched up by the wood, they are become much smaller pipes." (*Anat. of Plants*, p. 115.) Du Hamel also regarded them as similar to those of the bark, but rendered much smaller by compression. In the pine and fir they are disposed circularly around the axis, much like the sap-vessels, and alternate with them. (*Phys. des Arbres*, tome i. p. 41.)

In *Piscidia erythrina*, the proper juices are of a scarlet colour, and the vessels that contain them are therefore readily discerned wherever they exist. This plant has been selected by Hill to demonstrate the position of these vessels. In the bark they are collected into fasciculi, all the vessels of which contain coloured juices, and are disposed in a ring on the inner margin of the bark. Within this ring stands the alburnum, through the substance of which many smaller red vessels are distributed; and similar red vessels are more sparingly seen in every layer of wood, particularly in that which envelopes the pith. (*Construction of Timber.*)

Now the red vessels thus observed in the wood of the above-mentioned plant must either have been formed in the situations they occupy, or transported from some other place. The latter supposition is inadmissible, inasmuch as the wood of trees is formed by layers of new vessels superimposed on one another; and no removal of the old vessels, nor reproduction of new vessels within the old layers, ever takes place; consequently no actual transposition of vessels could occur, nor could new vessels be developed in the wood after it had been completely formed. If, however, an alternate deposition and absorption of matter go on into and from the cells, it is possible that the vessels might in this way become filled with a matter different from that which they originally possessed; but in the case before us, a readier explanation presents itself. The new matter of the wood is formed at the same time, and in the same place, as that of the bark; and through this new woody matter the red vessels were dispersed as well as in the bark. Consequently every addition made to the ligneous layers would furnish some vessels that contained these proper juices; and this, being annually repeated, would exhibit that intermixture of proper vessels with sap-vessels which is observed in all the ligneous layers of this and many other trees. Hence these *proper vessels* of the wood must be held to retain the position in which they were originally produced, and cannot be said to have approached nearer to the centre, but only, by the addition of new layers exterior to them, to be placed farther from the circumference of the tree. As Grew, therefore, held the alburnum to be a part of the bark, he might correctly say that these vessels "did once appertain to it."

Art. VII.—*Of Collections of the Proper Juices in the Cellular Tissue.*

In single cells. Besides this accumulation of the proper juices in certain vessels of the wood, it frequently happens that depositions of similar matter occur in all parts of the cellular tissue of plants. In the bark of the oak and poplar, and of other trees, resinous concretions are often found in the cells; they are situated irregularly, and, according to Malpighi, are observed even in very young bark. Sometimes the cells containing milky and resinous juices are so postured in the bark, says Grew, as to form cylindrical channels, which are neither parallel nor anywhere inosculated, but run, with some little obliquities, distinct from one another. They appear to be formed out of the cells, and are not bounded by any walls or sides proper to themselves, but only by those of the cells. (*Anat. of Plants*, p. 112.) They are often short and tortuous, always isolated; and are sometimes placed irregularly, at others disposed in a circular form. They occur sometimes in the pith, and possess very different sizes and figures. They have frequently been deemed a species of *proper vessels*, from the mere circumstance of their containing similar juices, and from possessing sometimes an elongated form; but they are organs which, neither in form nor in function, bear any resemblance to vessels. Mirbel proposes to name them *secretory canals*, and M. Link *cellular reservoirs*—the term certainly most generally applicable, and involving no hypothesis respecting either their formation or functions.

In cellular reservoirs. The manner in which these cellular reservoirs may be produced in the bark or pith is readily explained, on the supposition that a communication everywhere subsists between the vessels and the cells. One set of vessels has been shown to receive and carry sap to the leaves, and another to bring it back from them to the bark; and these two sets of vessels are everywhere in their course surrounded by cellular tissue. Hence the cells in every part may receive a portion of the fluid which the vessels are employed to convey. Thus in herbs, the cells both of the bark and pith are filled with fluid, which led Grew to believe that the sap was actually transmitted through those organs; but at the same time he delivers facts which, even in his own opinion, prove that it is derived directly from the vessels. Not only in herbs, but "in every annual growth, whether of a sprout from a seed, of a sucker from a root, or of a scion from a branch, the pith is always found the first year full of sap; but in the second year the same individual pith always becomes dry, and so it continues ever after. One cause whereof is, that the

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lymphæducts of the bark being the first year adjacent to the pith, they do all that time transfuse part of their sap into it, and so keep it always succulent. But the same lymphæducts the following year are turned into wood, and the vessels which are then generated and carry the sap stand beyond them in the bark; so that the sap, being now more remote from the pith, and intercepted by the new wood, cannot be transfused with that sufficient force and plenty as before into the pith, which, therefore, from the first year always continues dry." (*Anat. of Plants*, p. 124.)

All that is here said respecting the transfusion of the common sap from the vessels into the cells as it ascends through the wood, is equally applicable to the *proper juices* as they descend through the bark. During the first year of growth, both the sap and proper vessels are adjacent to the pith as well as to the bark, and each order may therefore transfuse its fluids into the cells of either. The common sap, from retaining its fluidity, is frequently removed by absorption, and the cells that contained it appear empty and dry; but where the proper juices are transfused, and become viscid or concrete, they are retained, and appear in different quantities and forms both in the bark and pith, according to the nature and properties of the fluids from which they are derived, and the texture and situation of the tissue into which they are poured.

In intercellular canals.

To these collections of the *proper juices* in the cells of the cellular tissue may be referred the opinions of those who describe them as existing sometimes in vacuities between the cells. Grew had remarked the occasional presence of these juices in cylindrical channels formed by these vacuities, to which M. Treviranus has given the name of *intercellular canals*. According to him, these canals not only contain the proper juices, but convey them to all the cellular parts of plants, and are the true *proper vessels* of the bark. We before saw that M. Kieser, after making the wood to consist almost entirely of spiral vessels, destined only to convey air, supposed the sap to be carried by these same intercellular canals. (Kieser, *Mém. sur l'Organisat. des Plantes*, p. 36.) With M. Treviranus, he also considers them as the real *proper vessels* of the bark, by which alone the juices are conveyed. (*Ibid.* p. 86.)

Opinion of De Candolle.

M. de Candolle considers the proper juices to possess no special organ for their conveyance, but to nestle in the cavities that surround them, and form sacs or reservoirs of various size and form. He distinguishes several kinds of these reservoirs, which vary with the figure of the containing sac. Thus, what others call "proper vessels," he designates by the names of tubular and fascicular reservoirs. In this, however, he appears to confound the "proper juices," destined immediately to the functions of nutrition and growth, with various fluid or solid matters, either simply deposited in the cellular tissue, or that have undergone subsequent alteration by the agency of a secreting organ. The reservoirs of the proper juices, and the juices themselves, are, he says, readily seen in many families of dicotyledons; but have not been observed with certainty, either in monocotyledonous or acotyledonous tribes. (*Organog. Vég.* tome i. chap. 11.) The reason of this seems to be, that in dicotyledons the bark, in which the proper juices are seen, is distinct from the wood, in which the common sap flows; and the colour, consistence, and qualities of the two fluids, therefore, at once point out their respective places; but in plants belonging to the two latter tribes there is no proper distinction of bark and wood; and the two orders of vessels, as shown by Malpighi in the instance of wheat, are associated together through the whole substance of the plant, which renders the discrimination of their common and proper juices more difficult.

Opinion of Dutrochet.

Besides two orders of vessels existing in the ligneous part of trees, M. Dutrochet describes a particular form of cell, which, in the wood, serves only as a receptacle for fluids; but to which, in the bark, he assigns a vascular function. This is the elongated cell observed by Malpighi, and represented by him in fig. 18, Plate XXXIX. M. Dutrochet, from the resemblance which its figure is said to bear to a spindle, has given it the name of *clostre;* and his representation of it is given in fig. 17, Plate XXXIX. These elongated cells form what Kieser and others have called the ligneous fibres. By M. Dutrochet they are regarded as reservoirs of the nutrient juices, and as containing secretions which impart solidity to the wood. In the bark, however, these same clostres are declared to be the organs in which the elaborated sap is contained, and by which it is transmitted to the roots to furnish the materials of their growth. The clostres, which thus convey the nutrient matter, ought not, he adds, to be confounded with the "proper vessels," which are the true secretory organs. These vessels are tubes of greater diameter than the clostres, and contain various excrementitious substances, as resin, &c. in different plants. (*Recherches Anatomiques*, &c. p. 36, 37.) According to M. Dutrochet, therefore, the elongated cells and vessels which exist in the bark and wood exercise functions precisely opposite; for whilst in the wood the corpusculiferous vessels convey the sap, and the cells are reservoirs for containing it, in the bark the cells are the organs which transmit the elaborated sap, and the vessels those in which the excrementitious matters are contained.

In our view, these notions are the reverse of fact, since we consider the vessels, both in the wood and the bark, as the organs by which the fluids are conveyed, and the various forms of the cellular tissue as the general receptacles into which they are in part deposited: they may, however, in some instances be retained in the vessels themselves, as well as in the cells.

Section II.

Of the Absorbent and Exhalent Systems.

Art. I.—*Of the Absorbent System.*

Connected with the vessels that distribute the fluids through organized bodies, is another system of vessels, by which extraneous matter is taken up to support the growth of parts, and supply the waste occasioned by the exercise of the various functions. To these vessels anatomists have given the name of *Absorbents*. The function which they perform is carried on either from the external surface, or from some internal part of the body; and its exercise, in animal bodies, may be distinguished into three kinds or stages. The first is that in which new or extraneous matter is taken up and added to the system, as in the absorption of substances from the skin, or of chyle from the intestines; the second is that in which substances previously separated from the fluids by secretion, but without becoming organized, are again taken up by the absorbents, and reconveyed into the blood-vessels, as in the absorption of milk, bile, and fat; the third kind is that in which the secreting organs themselves, and successively all the solid parts of the body, are removed by the action of the absorbent vessels. By plants this function is exercised to less extent, and seems to comprise only the first two kinds or degrees of it, viz. the primary absorption of extraneous matter, and the reabsorption of certain secreted matters; but in them there

does not appear any power of re-absorbing what has once formed an organized part of the system. Hence the formation of organized parts in plants is not accompanied, as in animals, by the unceasing removal of old particles; but the particles which have once become organized continue permanent until removed by some cause or process foreign to the living powers of the plant. When once, therefore, the organs of plants have become mature, they are exposed to decay only from the operation of foreign causes, and cannot be mined from within by that gradual loss of balance between the secreting and absorbing functions which the advances of age bring on the animal system. Neither, in the vegetable system, can the removal of organized parts under disease, any more than in health, have place; and, consequently, the several modes or stages of ulcerative absorption, so finely illustrated by the researches of Mr Hunter, belong not to the economy of plants.

As the function of absorption is thus of more limited extent in plants than in animals, so may we expect to find the arrangement of organs destined to its exercise. In the more perfect animals, the absorbent vessels are quite distinct from those which carry blood, are provided everywhere with glands, and, like the veins, are furnished with valves. From their beginnings, in all parts of the body, to their termination, they continually unite with one another, until, after a long course, they form at length two trunks, which deliver their contents into the large veins near the heart. As no common reservoir exists in plants, there is no such single point to which their absorbed fluids require to be carried. Hence their absorbents seem everywhere to have a very short course, to form no union with one another, but to deliver their contents at once into the sap-vessels adjacent to them. They appear to be destitute alike of glands and valves, and indeed, in an anatomical view, they can scarcely be considered distinct from the sap-vessels, but may rather be deemed ramifications from them; so that although we grant, with Grew, that the ordinary sap-vessels do not ramify one out of another, yet they certainly send off those fine ramifications which, from their office, we denominate the absorbents of plants.

In the root, the absorbents are capable of being demonstrated. When a plant is immersed in coloured fluids, many of its capillary absorbents become tinged through their whole course to their termination in the sap-vessels, proving them to be simple ramifications from these vessels themselves. A further proof of the identity of these two systems is derived from the fact, that any part of a sap-vessel is not only capable of emitting capillary absorbents from its sides, but of exercising itself an absorbent function, whenever its cut extremity is brought into contact with a fluid. These absorbents are formed very speedily and in great multitudes on the roots of annual plants; and even in perennial plants they appear, like the leaves, to suffer an annual decay, and to be reproduced with the return of vegetation.

M. de Candolle describes a structure as existing at the extremities of the roots and of the pistil, and also on the outer coat of seeds, which possesses a peculiar aptitude for absorption. To this structure he gives the name of spongiole: it is composed of small round cells, and in roots is situated at all their fibrous extremities. The entire body of each radical fibril is indeed made up of an analogous cellular tissue; but it is the extremity alone which actually absorbs, and which therefore possesses a peculiar absorbent or hygroscopic power. The pistillary spongioles are in like manner situated at the extremity of that organ, and absorb the fecundating liquor. The third variety, or seminal spongioles (*spongiolæ seminales*), are placed on the surface of the grain, apparently with great regularity; and by them the absorption of moisture is effected. Not only water, but coloured liquors, are absorbed by these spongioles, though the molecules of such liquids never enter the ordinary pores of plants, which pores must be infinitely greater than the apertures with which the spongioles may be furnished. This is the more remarkable, says M. de Candolle, when we call to mind that these colouring molecules traverse the compact and almost stony coats of seeds, and yet do not enter leaves whose tissue is so lax, and which are visibly furnished with pores that have the power of absorbing water when in contact with it. (*Organog. Végétale*, tome i. chap. 7.)

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But plants absorb fluids by other parts of their surface as well as by the roots. This absorbing power extends, in some of the lower tribes, over the entire surface of the vegetable, which is destitute of any organ analogous to a root; in other instances, where the roots are small and the soil arid, the plant derives almost all its moisture by the absorption of dews through the leaves. The experiments of Bonnet show that all leaves, both those of herbs and of trees, when brought into contact with water, are capable of absorbing it, and that the moisture thus absorbed is communicated through the vascular system of the leaf. The leaves of herbs he found to absorb nearly alike from either surface; but those of trees absorbed best by the lower surface. The petiole and larger riblets appeared to absorb much less than the other parts of the leaf. So great and general is this absorbing power, that vegetables, says he, may be said to be planted in the air, nearly as they are in the earth, the leaves being to the branches what the capillary rootlets are to the roots. (*Recherches sur l'Usage des Feuilles*, p. 22, 47.)

Absorption by leaves.

What then are the organs by which this function is carried on in the leaf? M. Bonnet imagined the vessels of the leaves to receive their fluids through the pores adjacent to them; and that the leaves, which had only few pores, possessed but little absorbent power. (*Ibid.* p. 20, 22.) He thought, also, that the hairs frequently distributed over the leaf attracted moisture, and might even act as absorbents; though he admits that many leaves which have only slight inequalities on their surface, without hairs, exercise an absorbent function. (*Ibid.* p. 47.)

External absorption by pores.

This subject has been since investigated by M. de Candolle, whose researches appear to confirm the account of Bonnet as to the absorbing power of the pores. According to him, these pores are found on all parts of the leaf except the riblets, which have none, but are covered with hairs. At the mouth of the pore a vascular net-work is always to be found, which he regards as a production from the larger vessels of the leaf. He asserts that pores are found only in those parts where vessels go to terminate, and not in others; and that in trees this structure occurs chiefly on the lower surface of the leaf, while in herbs it is equally seen on both surfaces. The stem in general has few or no pores, except where it is soft and herbaceous; and even then the pores occur only in the deeper green furrows, not on the prominent lines which bound them, and are usually covered with hairs. No pores are to be found on roots or bulbs or fleshy fruits, but most of the organs above ground are more or less furnished with them. Exposure to the air seems necessary to their formation; for plants, or parts of plants, that live beneath water or earth, are destitute of pores, but acquire them if brought into the free air. Exclusion of light prevents also the formation of pores; and hence etiolated plants are not furnished with them. (*Mém. de l'Instit. Nat.* tome i. p. 351.) In general, his anatomical researches respecting the ex-

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istence of pores in leaves agreed with the results of Bonnet's experiments on the absorbing power of their surfaces; and when we consider that all plants and parts of plants secluded from the air are at the same time destitute of pores, and of the power of absorbing by their surfaces, it may be inferred that the organs of absorption on the external surfaces of plants are the minute vascular productions which, in tender and succulent parts exposed to the air and light, everywhere perforate the cuticle, and form in it those innumerable orifices which we denominate pores.

Internal absorption;

But the function of absorption in plants is not confined to the taking up of extraneous matters. Many facts prove that, in every part where active vegetation exists, *internal absorption* is continually going on. The organs by which this absorption is immediately performed cannot, perhaps, from their extreme delicacy and minuteness, be rendered capable of anatomical demonstration; but certain facts which occur in plants, coupled with certain analogies derived from other organized textures, must, we think, carry complete conviction of their existence. In almost every part, and on every surface of animal bodies, the vessels which exercise absorption may be traced; but the mouths or orifices by which they actually absorb are scarcely ever to be seen. In one instance only, viz. in the intestines, have they been followed to their beginnings, and discovered in the act of exercising their appropriate function. (Gordon's *System of Human Anat.* vol. i. p. 70.) But though their orifices remain in other parts undiscovered, no anatomist hesitates to admit their existence when he sees the canals of the vessels themselves laden with blood, or milk, or bile; and seeing them thus to convey fluids whose colour manifests their presence, he equally believes them capable of absorbing and conveying other fluids, though they may not be visible to the eye. Believing further, that no solid part of the body, nor even fluid part that has been deposited in close cavities, can be removed in a natural manner from its place, but by the agency of these vessels, he comes to regard the simple fact of the disappearance of such solid or fluid part as sufficient evidence of its absorption.

in seeds;

Now the facts and analogies on which *internal* absorption rests in the vegetable system are precisely of the same nature, and the evidence of its existence is scarcely less complete. In every part of the cellular tissue of plants various substances have been found which must have been primarily derived from the vessels, the only organs which furnish new materials to the plant. These substances, however, often disappear from the cells, and are again to be detected in the vascular system. Thus, in the seed, as will afterwards be shown, the cells of the cotyledon contain a solid unorganized matter, which could have been originally deposited in them only by means of the vessels. During germination, this solid matter is rendered fluid, disappears from the cells, and is again to be traced in the vessels on its way to afford nutriment to the radicle and plume. We say, then, that this unorganized matter must have been taken up from the cells of the cotyledon, and conveyed into the vascular system, by the agency of absorbent vessels, which, it is probable, are distributed everywhere on the inner surface of these cells; just as, in the animal system, absorbent vessels are considered to take up the fat from the inner surface of the cells in which it is deposited, and convey it into the vessels of the animal.

This alternate absorption and deposition of the nutrient matter of seeds is sometimes strikingly displayed in the growth of potatoes. It frequently happens that potatoes lying in a damp cellar put forth shoots which grow to a considerable size, without the access of any foreign agents except heat, water, and air. On these shoots young bulbs, as large as the eggs of pigeons, are sometimes to be found, and the substance of the old bulb has in great part disappeared. In such cases, the matter from the cells of the old bulb must be considered as removed by absorption, and conveyed into the vessels of the shoot, where it was in part employed in forming the new organs of the young bulb, and in part deposited, to experience, perhaps, in some future growth, similar successions of removal and deposition. In the living parts of perennial plants, also, nutrient matter appears to be alternately deposited and absorbed from the cells during the active periods of vegetation; and in the cellular tissue of herbaceous plants a similar deposition and absorption of fluids seems to be frequently taking place; so that, in all the vegetating parts of plants, these alternate functions of secretion and absorption are more or less constantly exercised.

in bulb

in trun

A good illustration of the manner in which these functions are alternately exercised is afforded by an experiment of M. de Candolle. The parasitic plant called misletoe draws its nourishment, as is well known, from the tree on which it grows. M. de Candolle placed a branch of an apple-tree, bearing a stalk of misletoe, in an infusion of cochineal for five days. He then dissected it, and observed the coloured liquor to have risen through the wood and alburnum of the apple-branch, and reached the place of junction between it and the misletoe, which it strongly reddened; and from thence it penetrated into the woody part of the misletoe. There did not, however, appear to be a true anastomosis between the vessels of these different plants; but, at the base of the misletoe, where the parts were so deeply reddened, a minute cellular structure was observed. Into these cells the vascular system of the apple appeared to deposit its sap, and from them the capillary absorbents of the misletoe, distributed upon the cells, seemed, like the ordinary absorbents of roots, to take it up. (*Mém. de l'Instit. Nat.* tome i. p. 370.) From these and many similar facts it may be inferred, that absorbents, communicating with the vessels of the plant, exist in every part, and that the removal of all secreted matters from the cells and other close cavities of the vegetable, when effected by the living powers of the plant, is accomplished, as in animal bodies, by the exercise of an absorbent function.

Art. II.—*Of the Exhalent System.*

Organs exhalat

But from their external surface, and from the same parts as we have seen to exercise an *absorbent* function, plants, in certain circumstances, give off a large quantity of fluid by *transpiration;* and the organs by which this function is performed seem, from many considerations, to be the same as those by which, under other circumstances, absorption is accomplished. This function of transpiration is common to all terrestrial plants, and, with few exceptions, all are more or less furnished with pores; but it does not occur in aquatic plants, according to De Candolle, which are destitute of pores. Fleshy leaves and fruits, and the petals of flowers, which have but few pores, transpire little; and etiolated plants, which are destitute of pores, do not transpire at all. On the contrary, herbaceous stems and plants, which have numerous pores, throw off most fluid by transpiration. This general agreement between the existence of pores and the exercise of the transpiratory function leads to the presumption that they are the orifices through which the fluids are discharged; and if it be admitted that these pores are situated at the extremity of the fine ramifications that come

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off from the vessels, their fitness for such an office cannot be denied. Comparing these facts regarding transpiration with those previously stated concerning absorption, M. de Candolle is led to conclude that the pores on the surfaces of plants are the organs by which these functions are alternately carried on, according to the existing condition of dryness or humidity in the surrounding atmosphere.

Repulsive as this conclusion may at first seem to our ordinary conceptions of organized bodies, yet there are many circumstances in the structure and habits of plants that give to it great probability; so much so, that we ourselves had long since reached the same point by a route different from that pursued by M. de Candolle. It is highly probable that the exhalents of the leaves are simple ramifications from the larger vessels, like the capillary rootlets; and as they have no valves in their canal, there is no mechanical impediment to their exercising an inverted action. The sap-vessels themselves readily absorb even coloured fluids when inverted; and though their exhalent terminations are too fine to receive such fluids, yet why may they not, like the trunks from which they spring, be capable of taking up ordinary fluids in that manner? The fluids absorbed through the leaves must at once enter the sap-vessels, for there is no common reservoir to which they can first be carried; and it is extremely improbable that, from the same parts of the same vessels, exhalents and absorbents, capable of exercising only opposite functions, should at the same time arise. In the animal system the exhalents spring from arteries, and the absorbents terminate in veins; but in the less complex structure of plants it seems demonstrable that both orders of vessels must at once communicate with the same sap-vessels. It is therefore more probable to suppose that, instead of two distinct orders of vessels, as in animals, one only should be provided, capable, under different circumstances, of exercising different functions. This vicarious office of the organs under consideration leads to no confusion in its exercise; for the condition of the atmosphere, which favours transpiration, is that which removes from the leaves the power of absorption; and, on the contrary, absorption occurs only in a humid atmosphere, when, as Hales has shown, little or no transpiration takes place.

Besides exhalation carried on through visible pores, plants, like other bodies, lose their humidity by simple evaporation. This evaporation seems to go on in a moderate degree under favourable circumstances by day and by night, and is quite distinct from the copious transpiration that is carried on by the agency of solar light through the pores. That the pores are exhaling organs, was an opinion first advanced by Hedwig, and subsequently illustrated by De Candolle, Sprengel, Link, and Rudolphi. (*Organog. Végétale*, tome i. p. 86.) In like manner, though absorption may be carried on in certain circumstances through the pores of leaves, yet there are plants which largely imbibe water, but in which few or no pores have been detected. Thus, fleshy leaves which have lost their moisture quickly regain it either when plunged in water or exposed to rain, though they possess but few pores; and the aquatic algæ, says M. de Candolle, evidently imbibe water over their whole surface, though they are wholly destitute of pores. He supposes that, beside the ordinary pores which may be readily seen, plants may be furnished with others that are invisible from their extreme minuteness. By such pores we might account for the loss of weight which plants destitute of visible pores gradually undergo when exposed to the free air, and also for the increase of weight which mosses, and other plants equally destitute of pores, rapidly acquire when plunged in water. (*Organog. Végét.* tome i. p. 88.)

Internal secreting and absorbing organs.

The view thus presented of the *external* absorbent and exhalent vessels may probably be extended to the minute vascular productions which seem everywhere to spring from the vessels *internally*. If secreting and absorbing vessels be held to exist in every part of the plant, they must everywhere communicate with the vascular system; for it is from the vessels of this system that the matter of their secretions is primarily derived, and it is into the same vessels that, in many cases, these secretions are subsequently returned. Nor does the exercise of the two functions of secretion and absorption in plants present any apparent obstacle to the supposition of their being performed at different times by the same organs. Thus, when nutrient matter is deposited in the cellular tissue of the seed, it is destined only for a future use; and the purpose of nature would be defeated were an absorbent function to be at the same time employed for its removal. On the other hand, when this matter is again taken up during the germination of the seed, no secreting function seems then to be exercised in that part; for the organ itself, in many seeds, gradually wastes, and no fresh matter is deposited in it. Even when the cotyledon to a certain extent augments in size, its nutrient matter is continually drawn off for the support of the radicle and plume, and no fresh matter of the same kind seems to be then deposited; so that the same vessels which formerly exercised the function of secretion may, without disturbing the economy of the plant, be now employed in the exercise of absorption. As thus the two functions do not require to be performed in the same part at the same time, they may, if nothing else forbid, be exercised at different times by the same organs. In the animal system, where the organs themselves are removed, secreting and absorbing vessels must necessarily co-exist; and to maintain the integrity of parts, their functions must proceed at the same time, and to a certain extent balance each other; but as no similar operations appear to be carried on in the vegetable system, no such complex organization is required to sustain them.

Section III.

Of the Cellular Tissue.

Art. I.—*Description and Structure of the Cells.*

Definition.

The elementary organ denominated *cellular tissue* may be said to consist of a membranous substance, disposed into a great number of small circumscribed cavities, connected with each other, and arranged in rows or suites, generally in a direction opposed to that of the tubes, which represent the vascular system. From Grew it received the appellation of *parenchyma*, a term still often used in describing different parts of this tissue; by Malpighi, it was called the *utricular substance*; and it owes, we believe, its present name to M. du Hamel.

Description.

The cavities which distinguish its construction were called indifferently bags or bladders, pores and cells, by Grew; by Malpighi, utricles; by others, vesicles; and more commonly cells. The form of these cells varies so much, not only in different plants, but in different parts of the same plant, as to have authorized, in some degree, these different appellations. The tissue which they constitute enters into the composition of every organ in the more perfect plants. Of many herbaceous plants it forms the chief portion, and some of the lower tribes of vegetables, as the algæ, lichens, mushrooms, &c. are said to be wholly composed of it; in other words, no vessels can be

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actually demonstrated in them. In most cases it contributes greatly to modify the form of organs, and adds always to their bulk and strength. Nothing can exceed the diversity of appearance in figure, bulk, and texture, which it exhibits in the several parts, circumstances, and conditions in which it is placed. It represents sometimes a lax cellular substance, all the parts of which are succulent and transparent; in other instances it is compressed into a solid, opaque body, retaining but faint traces of its former cellularity; and in others, again, it is spread out into a most thin and delicate membrane, in which the cellular character is wholly lost. It everywhere envelopes and holds together the vascular system, and seems to be the general receptacle of almost all the vegetable secretions.

Figure of the cells;

The figure of the component cells of this tissue is exceedingly various. Sometimes they have nearly a globular or spheroidal shape; in other instances they are angular, and exhibit in their section a greater or lesser number of sides and angles, being in a few examples triangular; in others square, but more commonly hexagonal, the figure which collections of soft cells, mutually impressing each other, seem naturally disposed to assume. This form is represented in the transverse section of cells, fig. 28, Plate XXXVIII.; they seem in this figure, and in most of those given in different works, to possess double sides; but, as M. Kieser has remarked (*Mém. sur l'Organisat. des Plantes*, p. 91), this appearance is produced by the borders of the subjacent cells being seen through the transparent sides of the superior layer. In Plate XXXIX. fig. 16, is a representation of a transverse slice of the cellular part of sugar-cane, drawn from nature, and so thin as to exhibit only one layer of cells, in which the sides appear distinctly single; but, in a thicker slice of the same plant, fig. 21, comprehending more than one layer, the double appearance becomes very evident.

their size;

The size of the cells varies not less than their figure in different plants and in different parts of the same plant. In one of the plates of Grew they are represented as possessing twenty different sizes, from that of a minute pore, to the size of a common pea. Hooke examined them in cork, and in the pith of many plants. In cork he reckoned several lines of these cells or pores, as he calls them, and found there were about sixty placed endwise in one eighteenth part of an inch, or somewhat more than a thousand in the length of an inch; and, therefore, in a square inch above a million, and in a cubic inch above 1200 millions. (*Micrographia*, p. 114.) In this substance the cells are not visible by the naked eye, but become very distinct when highly magnified. In most plants, however, they are readily visible, and their appearance is familiar to every one.

When viewed in a longitudinal section, their hexagonal form is much less distinct, and is sometimes wholly lost. In fig. 22, Plate XXXIX., is a series of single columns of the cells of sugar-cane, in which each cell is, to appearance, bounded only by four sides. Similar representations are given by Hooke of the cells in cork, and by Kieser in most of the figures which exhibit longitudinal sections of the cellular tissue; but in some instances the hexagonal form is visible even in these sections. In fig. 23 of the same plate we have given, in outline, the appearance of two series of columns of these transparent cells, in which one series is seen behind the other, and gives somewhat of the confused double appearance exhibited in the transverse section, fig. 21.

contents;

The nature of the matter contained in the cells of this tissue varies according to the part in which it exists, and the peculiar powers of the plant. Both Hooke and Grew remarked, that in the pith and bark of succulent plants the cells were often filled with aqueous juices, and in the same plant, at other periods, they appeared empty, or filled only with air. In the seed, the cells of the cotyledons contain minute unorganized particles, which, at a future period, serve as nutriment for the young plantule. Other particles of still smaller size, of a resinous nature and a green colour, exist in other parts of this tissue, and bestow on the plant its verdure. In every part of the plant these cells are also the occasional receptacles of the peculiar fluids which both the sap-vessels and the proper vessels convey; and hence various gummy and resinous substances, corresponding in quality to the fluids previously existing in the vascular system, are frequently detected in them. In the pulp of fruits, the various acid, saccharine, and austere juices that we meet with, are contained in different modifications of this tissue; and it is into its cells that the osseous secretions, which constitute their shells and stones, are made. These facts prove not only the great importance of this tissue in the construction of the vegetable organs, but the active share it bears in the economy of their functions; and demonstrate likewise an universal communication between the vessels and the cells.

The sides of these cells, when emptied of their contents, and viewed through the microscope, appear to be formed by a very fine transparent membrane, which some maintain to be everywhere entire, and others to be perforated with pores. The same sources of error exist here as before noticed in similar microscopical observations on the vascular system; and, accordingly, the respective disputants maintain, with equal confidence, the same opinions with regard to the porosity or non-porosity of the cells, as they had previously held concerning the vessels. We must therefore call in the aid of other means besides those of the microscope, for determining the important fact whether the cells have or have not any direct communication with each other.

are closed cavities

Dr Hooke examined the films or sides of the cells of cork, of the pith of elder, and of many other plants, for the very purpose of discovering whether any direct communication existed between them; but "each cavern or cell," says he, "is distinctly separate from the rest, without any kind of hole in the encompassing films;" nor could he, with his microscope, nor by his breath, nor by any other way that he tried, "discover a passage out of one of those cavities into another." (*Micrographia*, p. 116.) Dr Grew describes the little cells or bladders that compose the bark of roots as possessing a spheroidal shape in most plants. When viewed with the microscope, their sides are as transparent as water; and "none of them," he adds, "are visibly pervious from one into another, but each is bounded within itself." (*Anat. of Plants*, p. 64.) Both Hooke and Grew, however, believed a communication to exist between the cells, from the fact of their containing liquor; and Malpighi held the same opinion from similar considerations; but they nowhere describe the mode or structure by which they conceived it to be accomplished.

Later writers have not only adopted this opinion, but professed to demonstrate the structure by which the communication is maintained. M. Mirbel describes the sides of the cells as composed of an extremely thin, colourless, and transparent membrane, which is commonly perforated with pores, the diameter of whose aperture is not perhaps the 300th part of a millimetre. These pores are ranged generally in transverse series, and through them, it is said, the cellular tissue both receives fluids from the vessels, and transmits them very slowly

through its cells. (*Exposition de la Théorie*, &c. p. 105.) M. Sprengel and some others adopt this view of the porosity of the cells; but it is denied by Link, Treviranus, and Kieser. The latter author declares, that notwithstanding all that has been said concerning the pores in the sides of the cells, his observations, made with the greatest care and exactness, have not enabled him to discover the slightest trace of them. The sides of the cells, he adds, are always formed by a membrane extremely thin, but altogether smooth and uniform; and the cells themselves have never an open communication with each other. (Kieser *sur l'Organisat. des Plantes*, p. 94.)

If, then, no pores exist in the sides of the cells for the reception and transmission of the fluids they contain, some other means must be provided for the accomplishment of these objects. M. Link, accordingly, supposes the juices to pass from one cell to another by *transudation*. M. Rudolphi thinks that a *decomposition of the fluid* is effected by the cells themselves, during which it is transmitted through their sides; and M. Dutrochet calls in the aid of electrical agency. To us there occur no probable means of accomplishing these operations, consistently with the integrity of the cellular structure, but the exercise of those alternate functions of secretion and absorption which, from so many other considerations, we have supposed to be carried on in every living part of the vegetable system.

Another question of importance in relation to the sides of the cells is, whether they are single or double; that is, whether each cell has a side of its own, or whether one side is in every position common to two cells. Mirbel asserts the former, and Kieser maintains the latter opinion. In fig. 29, Plate XXXVIII., is an outline representation of these double sides as given by Kieser. From the extreme thinness of the membrane, it is very difficult, he says, to distinguish this double structure; but where the cells are large, and a glass that magnifies highly is employed, each partition that separates two cells is distinctly seen to be composed of two membranes, which are sometimes separated about the middle of the partition, and united towards the angular points. (*Mém. sur l'Organisat. des Plantes*, p. 91.) MM. Amici, Dutrochet, De Candolle, and others, support this opinion. (See *Organog. Veg.* tome i. p. 21.) The existence of this double structure receives some countenance from the fact observed in the construction of the honeycomb by the late Dr Barclay, who says that each side of every cell in the comb is composed of two plates, or is double. (*Wernerian Transactions*, vol. ii.) It may still, however, be more properly said, that each side of every cell is truly single, and is rendered double only by coming into contact with the corresponding side of an adjacent cell.

When the cells have a regular hexagonal figure, and are equally distended with their appropriate juices, there is no reason to suppose that any vacuities are left between their sides or angles. Mathematicians have long since demonstrated a regular hexagon to be one of those figures that completely fill up a given space; and that no vacuities can exist either about its sides or its angles. Where, however, the cells deviate from this regular figure, and more or less approach to a spherical form, vacuities or interstices may readily be conceived to occur. These vacuities are said to have been first noticed by Grew and Leeuwenhoeck, and afterwards by M. Treviranus, who describes them as interstices left between the cells in their mutual approximations towards each other. He gave them the name of *intercellular canals*, as already stated.

On the other hand, MM. Mirbel and Rudolphi altogether deny their existence; but M. Kieser contends strenuously for it. He describes them as small interstices situated at the angles of the hexagonal cells, and formed not by any sides of their own, but by the mutual approach of three contiguous cells, and possessing, therefore, a prismatic form. These interstices he conceives to exist at every angle, and thus every cell to be surrounded by them. In fig. 29, Plate XXXVIII., the black angular points denote their place. By their conjunction with each other they form a canal, which, when the hexagonal figure is perfect, and the cells are ranged horizontally, extends both in a longitudinal and transverse direction; and when the cells are placed obliquely, the canals have a similar direction. Their size varies according to that of the cells, by the sides of which they are constructed; they contain and convey the proper juices in the bark, but in the pith are often dry; and their course is said to terminate only with that of the cells themselves, at the surface of the plant. (*Mém. sur l'Organisat. des Plantes*, p. 104.) Such are the organs which, as we have seen, M. Kieser considers to convey both the sap and the proper juices in plants. That in some circumstances they may exist, and become reservoirs of the sap or other juices, seems highly probable; but of the impropriety of ascribing to such casual productions the performance of the primary functions of the vegetable system, we have already spoken.

The cellular tissue, as described above, is that form of it which must be regarded as the most perfect. From various causes, however, it is subject to great alterations. In herbs, and in the pith and succulent parts of trees, the cells preserve their original form and appearance for a considerable time; but by the growth of the other parts, and consequent extension and compression they experience, they acquire in the bark and wood an elongated figure, and this both in a transverse and longitudinal direction. In the latter case they surround and connect the layers of vessels with each other, constituting what has been named the *parenchyma* of the bark and wood. In this form their size is often greatly reduced, their cavities sometimes obliterated, and their cellular character altogether effaced. In other instances traces of a cellular structure are occasionally visible, appearing in detached portions among the perpendicular vessels. In some plants the cells become elongated in a longitudinal direction, and yet preserve their capacity nearly unchanged. It was probably this form of cell that led Malpighi to regard sometimes as a vessel, what, in reality, appears to be only a series of elongated cells. To his representation of these cells, as given fig. 18, Plate XXXIX., we have before referred. M. Kieser considers these elongated cells as forming the ligneous fibres of the wood, and that the bark is almost entirely formed of them. (*Mém. sur l'Organisat. des Plantes*, p. 99, 101.) These cells, he says, were originally round; but in trees they become so much lengthened as to exhibit the form of a tube. It is easy, however, he adds, to detect transverse partitions in these seeming tubes, which, having often a diagonal direction, give to these cells the form of a double pyramid with sharp points. The membrane which forms these cells is, in all trees except the *Coniferæ* and some others, smooth, without pores, and transparent. (*Ibid.* p. 299.) To these organs Treviranus gave the name of fibrous utricles; by De Candolle they are called tubulated cells; and Dutrochet, from their spindle shape, denominates them, as we have seen, *clostres*. His representation of them, fig. 17, Plate XXXIX., corresponds with the foregoing description of Kieser.

From suffering compression in a transverse direction, the cells have frequently their longer diameter thrown

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into that position, and thus extend from the centre to the circumference of the plant. This position, as will afterwards be shown, was fully noticed by Grew and Malpighi. Leeuwenhoeck also observed it, but mistook the cells thus elongated for vessels, and considered their partitions as valves,—errors which M. Kieser, as well as others, duly points out. In this transverse direction the tissue forms partitions more or less large between the vessels, as will afterwards be shown; and by the obliteration of its cells it is frequently reduced to the condition of a solid membrane.

Ruptures of the cells.

Besides these more constant and necessary changes in the figure and character of the cellular tissue, it often suffers others of a more casual and accidental nature. In the pith, as the plant grows up, divers ruptures, says Grew, occur, oftentimes very regularly, and observed constantly in the same species of plant. These ruptures are sometimes prolonged, so as to form a tube of considerable length. (*Anatomy of Plants*, p. 120.) Others have observed similar canals in the pith, formed not by sides of their own, but by those of the adjacent cells, and very various in size and form. They have been called *lacunæ*, or reservoirs, contain a variety of substances, and sometimes, especially in aquatic plants, only air. As we have seen the cavities of the larger spiral vessels to be filled with vesicles, so the larger cells of the pith, according to Grew, frequently contain smaller ones, or are divided by cross membranes. A similar observation is made by Kieser, who likewise remarks that, in the empty cells of *Calla Æthiopica*, he has sometimes seen small round-headed bodies, supported on little peduncles, which spring from the sides, and point towards the centre of the cells. Small crystallized bodies are also occasionally found in the cavities of the cells, and within the intercellular canals. (*Mém. sur l'Organisat. des Plantes*, p. 94.) Of those changes in the character of the cellular tissue, by which its cells are converted into receptacles and reservoirs of the proper juices of the plant, we before discoursed when treating of the proper vessels. To such an extent does this change sometimes proceed, that, in aged oaks, and, according to Kieser, in guaiacum, and probably in many other plants, the whole cellular tissue becomes filled with these secreted matters, and the distinctive characters of the cells, and almost of the vessels themselves, are obliterated and lost.

Cells contain vesicles.

CHAP. II.

THE ANATOMY IN GENERAL OF THE COMMON TEXTURES OF VEGETABLES.

Preliminary Observations.

Nature of the common textures.

The elementary organs, whose description has so long occupied our attention, form, either singly or by their combination, all the other parts of plants. Some of the lower tribes of vegetables consist entirely of cellular tissue, in which no vessels are at any period to be seen; and, even in the higher orders, many parts exhibit no appearance of a vascular structure. There can be little doubt, however, of the existence of such a structure, since, physiologically speaking, we can form no just conception of the growth of an organized body, without associating with it the existence of a vascular system. In all plants the pith consists of a cellular tissue alone. In herbaceous plants this tissue forms their greater portion; but in trees the number of vessels is so great as to constitute the chief bulk of the plant. To certain forms of these elementary organs, whether existing singly or in combination, we have given the name of *common textures*, because they are very generally to be found in all plants, and in almost all parts of them, howsoever varied in quantity, proportion, and arrangement. These textures are familiarly known under the names of cuticle or skin, of bark, of wood, and of pith; to which may be assigned the general appellations of the cuticular, the cortical, the ligneous, and medullary textures.

Common Textures.

All the several textures just enumerated are readily distinguished by their different places and characters in the section of most arborescent plants, in which they commonly appear well defined, and perfectly distinct from each other. In many plants, however, both herbs and trees, this distinction of parts is not preserved; but, with the exception of the cuticle, all the other textures are blended together through the entire substance of the plant, as was long since noticed both by Malpighi and Grew. "In the stalk of maize or Indian wheat," says Grew, "the work of nature appears less diversified; in which, although there are the same parenchymous and ligneous parts as in all other plants, yet is there neither bark nor pith, the vessels being dispersed and mixed with the parenchyma, from the circumference to the centre of the stalk." "The like structure," he adds, "may also be seen in the sugar-cane and some other plants." (*Anat. of Plants*, p. 104.) Similar observations were made by Malpighi, not only on different species of wheat and sugar-cane, but on ferns and palms. "In ferns," says he, "the vascular fasciculi are numerous, but placed without order, and are everywhere sustained by the intervening cellular tissue, the cells of which are sometimes much smaller than the orifices of the vessels themselves." *Anat. Plantar.* p. 24, 25.) This structure is represented in the transverse section of the sugar-cane, Plate XXXIX. fig. 25; and in a similar section of the palm, fig. 26 of the same plate.

Their position various.

This variety of structure, thus clearly described, and distinctly delineated in the works of Malpighi and Grew, has likewise been noticed by M. Desfontaines. Vegetables, according to him, may be distinguished into two divisions: 1*st*, Those which have no distinct concentric layers, whose solidity decreases from the circumference towards the centre, and whose pith is interposed among the vessels, and does not extend in divergent rays: 2*d*, Vegetables which have distinct concentric layers, whose solidity decreases from the centre towards the circumference, and whose pith is contained in a longitudinal canal, and extends in divergent rays. The former structure he considers as peculiar to plants whose seeds are monocotyledonous, and the latter as belonging to those which have dicotyledonous seeds. (*Mém. de l'Institut. Nat.* tome i. p. 478.)

Theory of Desfontaines;

This opinion, though partly correct, is not universally applicable. That many plants which spring from monocotyledonous seeds are destitute of concentric layers, and have no distinct bark or pith, is certain; but it is not less certain that many herbaceous plants, which are produced from dicotyledonous seeds, are pretty much in the same condition, being equally destitute of concentric layers and of divergent rays, and in which the bark and the pith must be regarded as one continuous structure. On the other hand, some monocotyledonous plants, as M. Desfontaines admits, may deviate a little from the prescribed conditions. In a paper on the organization of such plants, M. Mirbel, who regards this doctrine as the most important step made of late years in Vegetable Anatomy, says, nevertheless, it would be erroneous to assert that they have never a bark. In several species of plants he produces examples to the contrary; and adds, that in some instances their diametral growth goes on at the cir-

imperfect.

Common Textures.

cumference, which would seem to approximate them to dicotyledons. As, however, there is no appearance of divergent rays, or of concentric layers, these examples are considered by him rather to confirm than overturn the theory of M. Desfontaines. (*Annales du Mus. d'Hist. Nat.* tome xiii. p. 67.) But if in this theory its second division embrace only those plants in which the concentric layers are perfect, and divergent rays exist, then it excludes a great number of herbaceous plants, whose seeds have two cotyledons; and if the absence of these regular layers, and of divergent rays, serve as a passport to the first division, then many of these same plants must be admitted among those whose seeds have but one cotyledon. The theory of M. Desfontaines, therefore, rests on too partial an observation of the structure of plants.

Section I.

Of the Pith or Medullary Texture.

The pith (medulla) of plants, when present, occupies the centre of the stem, where it is commonly surrounded by a circle of vessels which construct for it an appropriate canal. In the succulent shoots of trees, its proportion to the other parts is generally large; but it diminishes as the tree advances in age, and is frequently entirely obliterated. Where the vessels of the wood are few in number, as in herbs, only a few fasciculi are seen to surround the pith, and the intervening spaces are occupied by a boundary of thickened cellular tissue. In some plants, again, no pith whatever exists, but the stem is hollow or tubular. In other instances, and especially in roots, the centre of the stem is occupied by vessels; and in others, both cells and vessels, promiscuously blended together, constitute the centre of the stem.

In those plants where the pith is present, and possesses its most perfect form, it is seen to be composed entirely of cellular tissue, possessing often very different shades of colour, but, in its anatomical characters, resembling exactly the description already given of that tissue. Its bulk in different plants is exceedingly different, as are also the form and size of its cells. It is frequently entirely insulated by the surrounding vessels, but is often continuous with the cellular tissue of the bark. Its cells contain, especially in the early age of the plant, aqueous fluids, which afterwards disappear, and then the cells become filled only with air. The "proper juices" of the plant may also be sometimes detected in the cells of the pith. Of the ruptures produced in it by desiccation and other causes, we have already spoken in discoursing of the cellular tissue: they occur particularly in succulent plants, where the cells are large, and their sides thin; so that as the plant advances to maturity, the pith breaks and shrinks up, making the trunk a pipe. (Grew's *Anatomy of Plants*, p. 129.) We have also noticed the fact, that, within the cavities of the larger cells of the pith, new vesicular productions are sometimes found.

Grew speaks of the existence of vessels in the pith of certain plants, as in that of the fig and the pine; but he adds, that they are usually so postured as to form a ring about its margin. (*Anatomy of Plants*, p. 119.) They are doubtless to be considered as enlarged *proper vessels*, which made a part of the first ligneous circle, and have retained therefore nearly the situation in which they were originally formed. Hence, as he observes, they are of divers kinds, answerable to those of the bark, containing in the fig a milky juice, and in the pine a resinous substance. Similar vessels, containing a "proper juice," were observed also in the pith of elder by Malpighi, who seems to regard such appearances as common where the contained juice concretes or possesses a dark colour. (*Anat. Plantar.* p. 4.) It is probable, however, that the organs here considered to be vessels may in some cases be cells, into which these juices have been poured; but where real vessels of this kind are found, they are not to be considered as a part of the original structure of the pith, but occurring only in consequence of the changes which the vegetable body undergoes in the progress of its growth.

Its nature.

The general nature of the pith is thus clearly announced by Grew. "Although," says he, "it have a different name from the *parenchyma* in the bark and the *insertions* in the wood, yet, as to its substance, it is the very same with them both; whereof there is a double evidence, viz. their continuity and the sameness of their texture;" so that all these parts are "one entire piece of work, being only filled up in divers manners with the vessels." (*Anatomy of Plants*, p. 119.) This continuity of the pith with the cellular tissue of the bark, by means of the insertions or transverse ranges of *utriculi*, as he calls them, is also adduced by Malpighi as evidence of the similarity of their nature, and of the pith being, as it were, an intercepted portion of the bark (*Anat. Plantar.* p. 4, 30); an opinion which seems abundantly confirmed by the intermixture of the medullary and cortical textures in many plants, in which, as already remarked, the distinctive characters of bark and pith are alike lost, and the entire stem exhibits only one uniform appearance of structure.

Errors concerning it.

The term *medulla*, employed by the ancients to note this texture, derived its origin, no doubt, from the resemblance which the pith in the centre of trees bore to the marrow in the bones of animals; and as the same term, in animal anatomy, was incorrectly employed to express alike the marrow in the bones and the nervous substance in the vertebral column, so the same latitude of signification has been extended to the vegetable system. Hence, as Malpighi remarks, the medulla in vegetables was regarded as analogous in its nature to the brain of animals,—a doctrine which even later writers have continued to espouse. It is not our present intention to describe the uses of the pith, but only to remove erroneous opinions concerning its nature, and restore to it that just anatomical character long since assigned it by Malpighi and Grew, and which some writers have of late put forth as a considerable novelty.

Section II.

Of the Wood or Ligneous Texture.

The wood.

Immediately surrounding and enveloping the pith is the part called the wood (*lignum vel lignea portio* of Malpighi). It is essentially composed of vessels and of cellular tissue, but combined in such an infinite variety of proportions, and exhibiting such a boundless diversity of forms, that it is difficult to seize even its more general features, without the risk of extending our description beyond the limits which our plan necessarily prescribes.

Description.

Except in those vegetables in which no vessels have been hitherto demonstrated, but in which they must nevertheless be presumed to exist, this texture may be considered to form a part not only of every plant, but of all its organs; for into whatever part fluids are conveyed, vessels must be supposed to extend; and wherever vessels are present, cellular tissue is to be found: hence, in its distribution, it may be considered the most universal of all the textures. In trees, the vessels, as we have frequently remarked, are very numerous, and, when viewed in a transverse section, are seen to be disposed in layers or concentric circles around the axis, and to stand also in

In ordinary trees.

Common Textures.

lines or radii, diverging from the centre of the tree. (See fig. 4, Plate XL.) Between each line or ray of vessels a thin partition of cellular tissue is interposed, which extends in the direction of the ray, through the entire substance of the wood. At certain distances, varying in different trees, thicker transverse portions of the same substance are placed, and are readily distinguishable in almost every species of wood. Between each layer that is annually added to the wood, and each of the smaller layers that go to the formation of the larger one, cellular tissue seems also in some trees to be longitudinally interposed; so that it is probable that in both directions each fasciculus of vessels is intercepted by cellular tissue, and that in such trees no two fasciculi are on any side in immediate contact with each other. It is even probable that the individual vessels which contribute to form the fasciculi are themselves connected by intervening cellular tissue, which acts like the *neurilema* that holds together the filaments of the fasciculi in the nerves, or the cellular substance that connects the primary filaments in the muscular fibres of animals. In this manner, the whole vascular system of the plant is everywhere connected and held together by cellular tissue. Of this tissue, and the different figures its cells acquire, from the different modes and degrees of compression to which they are exposed, we have already spoken.

In palms.

In many trees, however, as palms, the vascular fasciculi, though numerous, are much less abundant than in the examples just referred to. They are consequently placed at a greater distance from each other, and, not being disposed in regular lines, do not constitute that radiant appearance so common in ordinary trees, but are promiscuously dispersed through the cellular tissue. (See fig. 26, Plate XXXIX.) As this tissue itself is not, from the same causes, compressed either in the direction or to the extent before described, the smaller membranous partitions that divide the vascular radii from each other are not produced; neither, for similar reasons, is there any distinct appearance of the larger partitions that, at certain distances, intersect the diameter of other trees. The cellular tissue, therefore, in such plants, retains more of its primitive character, and appears everywhere to surround the vascular fasciculi, but nowhere to be so compressed as to form solid partitions between them. In some plants which possess this structure, as the sugar-cane (fig. 25, Plate XXXIX.), the cells indeed retain their perfect forms; and even the fasciculi of vessels, though standing at considerable distances from each other, have towards the centre of the plant a symmetrical arrangement. This latter circumstance is observable in many other plants, which have even fewer vessels than the sugar-cane; so that it is probable that, in the first instance, it takes place in all; and that the irregular position of the vessels in the palm and similar trees, particularly towards their circumference, proceeds from the peculiar modes of their growth, and are not a primary condition of their structure. This intermixture of the vessels and cells in the plants now under consideration extends from the circumference to the centre, so as to constitute their entire bulk, to the exclusion of bark and pith; unless we choose rather to say that in such plants the medullary, ligneous, and cortical textures, are all blended together.

In herbs.

In other examples the vessels form a still smaller portion of the ligneous texture, consisting only of a few fasciculi, which stand at considerable distances from each other, the intervening spaces being occupied by cellular tissue, which forms the chief bulk of the plant. (Fig. 15, Plate XXXIX.) Though few in number, the vessels, however, are symmetrically disposed, and in the same species preserve always the same position, the fasciculi being placed at the same relative distance from each other and from the common centre of the pith. Sometimes, instead of a few solitary fasciculi, they consist of several ranges, forming an imperfect sort of concentric layers; and in such examples the ligneous texture is commonly separated by distinct but irregular marks from the two other textures. In these plants the cellular tissue preserves its characters, and exhibits no appearance of divergent rays.

Causes of its varieties.

The three modes of arrangement above described appear to constitute the chief varieties of structure in the ligneous texture; but in each variety, and through every stage by which they graduate into one another, the greatest diversity of forms prevails. Each species of plant has its peculiar *internal structure*, as well as its *external* form; and this seems to be in a great measure determined by the number of vessels that enter into its composition, and their peculiar mode of arrangement. If the vessels are few, the cellular tissue is large in proportion, and its characters are distinct and well preserved;—if they are numerous, and disposed in rays, the tissue is compressed in various directions, loses more or less completely its cellular character, and forms alike those divergent rays or transverse partitions already so often noticed, and those thin membranous expansions or *fasciæ* which, both in the bark and wood, are seen sometimes to cover the vessels in a longitudinal direction. Though the whole of the ligneous texture is thus made up of vessels and cells, variously formed and blended together, yet many writers speak of ligneous fibres, which some describe as consisting of vessels, others of cells, and others of an assemblage both of cells and vessels.

The manner, too, or rather the place, in which the vessels are developed, in perennial plants, will greatly contribute to vary the appearance of the ligneous texture. In those trees whose diameter is annually increased by the formation of new vessels around the cylinder of older wood, the new parts must necessarily present in their longitudinal section the appearance of annual layers superimposed on one another, and, in their transverse section, that of concentric circles; but in palms and similar trees, where the development of new parts seems to be accomplished in a different manner, their appearance, under similar sections, may be expected to be different.

Structure of palm.

In a longitudinal section of the palm, says M. Desfontaines, we discover an assemblage of large ligneous fibres (that is, vascular fasciculi), solid, smooth, and flexible; and these are composed of others still smaller, which are firmly united together: they mostly run parallel to the axis of the trunk, from the base to the summit, without interruption; but some proceed obliquely, and cross the others at angles more or less sharp. (See fig. 24, Plate XXXIX.) In a transverse section of the same stem, continues the author, we remark neither concentric circles nor transverse partitions; but the fasciculi of vessels, placed without order by the side of each other, are enveloped by the cellular tissue, which fills up all the intervals: they sensibly approach each other, harden and diminish in size in proceeding from the centre to the circumference (see fig. 26, Plate XXXIX.); so that the stem has much more strength and solidity near the surface than in the interior,—an organization quite distinct from that of ordinary trees.

Their growth.

The cause of this diversity of structure seems to be amply accounted for by the different modes in which the growth of these trees is accomplished. When the seed of a palm is sown, the leaves, says M. Desfontaines, successively develope and augment in number for four or five years; the neck of the root augments in the same proportion; the bulbous part, formed by the re-union of

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the petioles of the leaves, increases insensibly; its solidity augments, and at length the stem rises above the earth with all the size it ever acquires. Its figure is cylindrical from the base to the summit; and if the diameter be measured at different epochs, it will be seen, as Kæmpfer had already remarked, not to increase. The palm, therefore, is a regular column, whose summit is crowned with leaves, disposed above each other circularly: those which grow in spring shoot always from the top; the older ones, placed below, dry, and when they fall leave circular impressions, which furrow the surface of the stem, and mark its years until it has ceased to grow.

If next we examine the interior, we discover, as M. Desfontaines thinks, the true reason why the stem rises in a column, and does not, like other trees, yearly augment in size. This was done by M. Daubenton, who states that every leaf of the date-palm, in proceeding from the bud, is formed by a prolongation of the vascular fasciculi and cellular tissue which exist in the trunk of the tree, as is apparent in the petiole of the recent leaves, and of the dried ones that adhere to the trunk. The elongation of the trunk is produced, therefore, by the leaves which annually proceed from it; and as the parts which form these leaves spring from the centre, they always, as they shoot, force the older leaves outwards. Hence, therefore, as the augmentation of these trees originates at the centre, all the parts capable of displacement must be pushed outwards, just as the new layers of bark and wood, formed annually in ordinary trees, force outward the older layers of bark exterior to them.

Effects of growth on structure.

In these latter trees, continues M. Daubenton, the recession of the bark has no limits so long as new parts continue to be formed beneath it, because the new cortical layers are flexible, and the older ones readily break and give way; but in the palm the substance of the trunk has more compactness as we approach the circumference, and, at a certain point of density, it no longer yields to the central force of the interior parts; so that when this point is reached, no further enlargement takes place; and hence the date-palm scarcely exceeds ten inches diameter. It is for similar reasons that the trunk of the date-palm is of the same size through its entire length; for, in proportion as the tree rises, the exterior parts of the trunk lose successively their flexibility; and when they have acquired a certain degree of density they no longer yield to the force from within; and as this is equally the case in all parts, the trunk is necessarily of the same size throughout. (*Mém. de l'Instit. Nat.* tome i. p. 482, &c.)

It is further evident that, in this mode of growth, no appearance of concentric circles, similar to those of ordinary trees, can have place; for, by the growth at the centre, the exterior vessels are continually displaced from their original positions, are more and more compressed as they are forced towards the circumference, and present in their transverse section that irregular distribution which they have been described to possess. Hence the cylindrical figure and the absence of concentric layers are as necessary consequences of the mode of growth in these trees, as the presence of those layers and the conical figure are of the mode of growth in ordinary trees. The greater solidity of the parts at the circumference is clearly to be ascribed to the same cause; and even the want of regular transverse partitions must in part also have a similar origin, and be ascribed, perhaps, in part to the smaller number of vessels which these plants possess, as well as to their irregular distribution. From this difference in their mode of growth, these two great divisions have received different names: those which, like our ordinary trees, augment in size by the deposition of new matter near the surface, are named Exogenous; and those which, like palms, grow from within, Endogenous.

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Section III.

Of the Bark or Cortical Texture.

The bark, in trees,

This texture, in its component parts, resembles that of the wood, being made up, like it, of vessels and cellular tissue intimately connected with each other. Its structure, as a distinct texture, is best characterized in the bark of ordinary trees, as it is there separated, in a great measure, from the ligneous texture. As in these plants a new layer of vessels is annually made to the wood, so a similar but much thinner layer is yearly added to the bark, to which the name of *liber* has commonly been applied. These vessels are at first straight, and run parallel to the axis of the trunk; but, by the successive formation of new layers beneath them, they are gradually forced outward, become separated more and more from each other, and, touching in a few points only, exhibit at length a reticulated figure (see fig. 24, Plate XXXVIII.), the meshes of which yearly augment in size, from the greater space over which they are continually spread.

is united to the wood.

Between the vessels thus annually formed, a considerable portion of cellular tissue is interposed, which, in the young and succulent state of parts, contributes chiefly to the thickness of the bark. This tissue is variously compressed by the vessels, so as to form *transverse* partitions between them, which, in the vine, the oak, and many other trees, as both Grew and Malpighi remarked, are seen to be continuous with those of the wood; and in this way the two textures are united together. In the expressive language of Grew, the bark, therefore, does not "merely surround the wood as a scabbard does a sword, or a glove the hand, but is truly continuous with it, as the skin of the body is with the flesh." In the willow and other trees, when full of sap, the bark is so easily separated that it seems to have no connection with the wood; but this is supposed by Grew to arise merely from the extreme fineness and tenderness of the vessels that are annually formed in that part, and which on that account oppose no obstacle to the separation. (*Anat. of Plants*, p. 129.) It is probable, however, that the cellular tissue forms the only direct connection between the cortical and ligneous textures; and that, if a vascular communication exist, it is only, as in all other cases, through the medium of that tissue.

Altered by pressure.

Besides the transverse compression which the cellular tissue experiences from the vessels, it is compressed in the opposite direction by the formation of the new layers of bark and wood beneath the older bark. These in the progress of their growth exert an expansive force outwards, so that the cells of the tissue are made to assume an oblong or flattened form in the direction of the vessels of the trunk, or sometimes to form a thin *fascia* upon the vessels, in which the cellular character is nearly or entirely obliterated. It is by the continued exertion of this force acting on the exterior and desiccated layers that these latter ultimately crack, producing figures of different sizes, which have frequently the shape of rhombs, the fissures of which represent, according to Grew, the position and track of the vessels in their reticulations. (*Anat. of Plants*, p. 129.) The spaces or meshes formed by these reticulations are always filled up by cellular tissue, which, in the opinion of Malpighi, originates from the vessels themselves.

Both in the vessels and cells of this texture, collections

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of the "proper juices" frequently occur; especially in plants in which these juices are of a viscid nature, and disposed to concrete; as was before remarked, when treating of the proper vessels. Similar collections of matter, originally existing in the bark, are likewise met with in every layer of wood, and even in the pith of certain trees. It is only in plants in which the "proper juices" are coloured, or disposed to concrete, that this intermixture of the cortical and ligneous textures has been traced through the whole substance of the tree; but it is probable, from the conjunction of the vessels of the bark and wood at the period of their formation, that it is common to other plants, the nature and properties of whose juices afford no clew to its detection.

The bark in herbs;

In most herbaceous plants, the cortical texture is not so clearly distinguished from the ligneous, since in them the greatest variety obtains both in regard to the number and relative position of the sap and "proper vessels;" and very frequently the cellular tissue is quite continuous and of uniform appearance through the entire substance of the plant. In general, however, the sap-vessels occupy the inner place, and are surrounded by the "proper vessels," disposed either in rings or distinct fasciculi, more or fewer in number. Sometimes the sap-vessels seem to be placed exterior to the others; and hence it is difficult to discover the true place of the "proper vessels" in such plants, unless the nature of their juices conduct to it. From the position of the vessels, therefore, it is often difficult to define the boundaries of the cortical and ligneous textures; and, for the reason already assigned, the cellular tissue rarely affords much assistance. According, however, to the number and disposition of the vessels, this tissue, even in these plants, suffers a certain degree of compression, so as to form thickened boundaries around the fasciculi, or sometimes large transverse partitions, which communicate with those of the wood, in which, though the figure of the cells is more or less altered, the cellular character is usually preserved.

in palms;

In other plants, the intermixture of "proper vessels" with those that carry sap seems to be general through the whole plant; and consequently no distinction can be made between the ligneous and cortical textures. In such plants the "proper juices" must be considered to exist in every part; and accordingly Malpighi, as we before remarked, points out a *vas proprium*, or "proper vessel," as accompanying every fasciculus of vessels in different species of wheat. (*Anat. Plantar.* p. 24.) From the similarity of structure in palms, and especially from their mode of growth, there can be little doubt that a similar intermixture of the two kinds of vessels prevails everywhere in them; and with respect to these plants, what has already been said of the construction of the ligneous texture, is equally applicable to that of the bark.

We have thus given a very brief and general view of the principal textures that enter into the construction of plants, and pointed out the more prominent diversities of character and appearance which they exhibit, as well in their simple as in their more complex forms, and as they exist either separately or variously intermingled together. Our descriptions have been confined entirely to the trunk or stem; but, with slight variation, they are applicable equally to the root and branch, in which a similar combination of the elementary organs obtains. In the root, however, they commonly exist in a more compressed and compacted form, so that the ligneous texture is seen chiefly to predominate, frequently to the entire exclusion of the pith, and often in great part also to that of the cellular portion of the bark. This, however, is not universal, especially in annual plants, some of which, as the carrot and others, particularly in a cultivated state, are distinguished by the very large portion of cellular tissue which enters into the construction of the cortical texture. Of the modifications of these several textures, as they exist in leaves and other organs, we shall have occasion to speak when we come to treat of them individually.

in roots and branches;

Common Textures in leaves.

Section IV.

Of the Connection subsisting between the Vessels and Cells in the several Textures.

Mode of connection of vessels and cells.

In our discussion of these several textures, we have noticed only in a general way the direct means by which the vessels and cells that construct them are connected with each other; but, when treating of the sap-vessels, of the absorbent vessels, and of the cellular tissue, we endeavoured to show that an universal communication obtains between these elementary organs, and consequently inferred that some mode of connection, by which it can be accomplished, must have place. Grew considered the vascular and cellular parts to be connected with each other, not only by the transverse partitions of cellular substance that intercept the vessels, but "*per minimas partes organicas;* that is to say, the parenchymous fibres are wrapped round about the vessels, or at least interwoven with them, and with every fibre of every vessel, as in very white ash or fir wood may be observed." (*Anat. of Plants*, p. 121.) These fibres Grew elsewhere considers as vessels, and consequently must be regarded as maintaining a vascular connection between these organs. In a description of the young branches of chesnut and oak, Malpighi delineates minute filaments springing on every side from the vessels of the wood, and continued into the adjacent cellular tissue (*Anat. Plantar.* p. 27); but he does not state whether they are to be regarded as vessels or simple fibres. He elsewhere describes minute vessels as surrounding the cells of the trunk like a network, and thinks it probable that the cells of the transverse septa are similarly furnished with vessels. In the cells of the pith of elder (*sambucus*), and of some other plants, the vessels are very abundant, and in every case are probably derived from the straight ligneous fibres (vessels) both of the bark and wood. (*Ibid.* p. 29.) Indeed he held it probable that the nutrient fluids moving through the vessels were in all parts poured into the cells, and there undergoing a certain preparation, were afterwards mixed with more recent juices, and with them taken up and applied to the support of the young buds and leaves. (*Ibid.* p. 30.) This doctrine has since been held by Darwin and Knight, and it necessarily supposes a vascular connection between the vessels and the cells, by which the functions both of secretion and absorption can be performed. The microscopical observations of Leeuwenhoeck, already noticed, supply further evidence in support of this opinion.

Opinion of Grew.

of Malpighi.

In the hypothesis of Mirbel both cells and vessels are considered as formed out of one and the same membrane. He rejects, therefore, the aid of all intermediate organs as necessary to connect them together, and supposes a communication to be everywhere maintained between the vessels and cells, by the medium of pores in their sides. As, however, these pores are nowhere proved to have existence but in the imagination of the author, we may altogether reject their agency in maintaining a communication between the vessels and cells of plants. In the opinion of M. Kieser, the conjunction of the cells with the vessels is extremely simple, the sides of the cells, says he, being contiguous to the sides of the vessels. (*Mém. sur l'Organisat. des Plantes*, p. 94.) But mere contiguity of parts does not amount to connection, much less does it afford any information concerning the actual communica-

of Mirbel.

of Kieser.

tion that exists between these organs. In addition, therefore, to connection by cellular substance, it seems absolutely necessary to suppose also the existence of a vascular structure, which shall at once serve as a medium both of connection and communication.

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Before concluding this branch of the subject, we may observe that the structure of the cellular tissue, and its relation to the vascular system in plants, appear, in many points, to resemble that of the adipose cells, and their relation to the vascular system of animals. These cells are described as minute close cavities, possessing no apparent communication with each other; and within them adipose matter is alternately deposited and removed. Now the deposition of this matter could only be accomplished by secreting vessels which terminated in the cells, and its removal be effected by absorbents which originated from them; and accordingly both blood-vessels and absorbents are found to be present in this texture; but neither the secreting nor absorbing orifices have ever been actually observed. Within the cells of the cellular tissue of plants the alternate deposition and removal of various matters are not less certain; and in the germinating seed the matter that actually existed in the cells is found afterwards in the vessels. We are led, therefore, or rather we are driven, not only by the direct exclusion of all other alleged means of communication, but by a close analogy in the exercise of these animal and vegetable functions, to conclude, that secreting and absorbing vessels must be employed to deposit and remove the secreted matter from the cells of plants, in the same way as they are considered to effect similar depositions and removals of adipose matter from the cells of animals: and as this alternate function seems to go on in every part of the plant capable of active vegetation, it may further be inferred that a vascular communication exists between the vessels and cells in all parts of the vegetable system.

By means of this general communication between the vessels and the cells, we are enabled to assign satisfactory reasons for some puzzling phenomena, which have occurred in relation to the movements of the sap. It is by this alternate action of secretion and absorption that in young plants we must suppose the cells of the pith, during the first year, to be filled with fluid, and to be rendered dry for the most part ever after. In like manner, the surface of the bark in contact with the wood appears in some trees, as the birch, to be rendered moist during the rise of the sap in spring; which led Dr Walker and others to suppose that the sap rose in part between the bark and the wood,—an opinion not at all probable in itself, and certainly not supported by what is observed in most other trees. The fact, however, is easily explicable, on the supposition that the sap was transfused from the alburnous vessels of the wood, in the same manner as, at a later period, it is secreted in the same part, but in a different form, by the vessels of the bark, to form the new matter that is annually added to the tree.

That the sap of plants was capable of moving in a *lateral* direction, was inferred by Malpighi, from the fact that parts lived and grew when the perpendicular vessels that supplied them with nutriment had been destroyed. (*Anat. Plantar.* p. 13.) The experiments of Hales afford more decisive evidence regarding this lateral movement of the sap. He cut two large gaps in the opposite sides of an oak-branch, at four inches distance from each other, carrying the incisions down to the pith: the branch nevertheless absorbed and perspired water, but only in half the quantity that another similar but uncut branch did. In a branch of cherry-tree he made four similar cuts down to the pith, at four inches distance from each other, and opposed to the four points of the compass: the branch notwithstanding absorbed, in forty-eight hours, twenty-four ounces of water. (*Veg. Statics*, p. 128, 3d edit.) And when similar incisions were made on branches while still attached to the tree, their leaves continued green nearly as long as those of other branches in a natural state; whence he justly inferred that, at these gaps made in the branch, a lateral movement of the sap must have taken place. Experiments of a similar nature have been made, and like results obtained, by Mr Knight (*Phil. Trans.* 1808); so that it seems clear that in certain circumstances a lateral movement of the sap must have place.

How effected.

In what manner, then, must we suppose this movement to be accomplished? Grew supposed the cellular tissue, that stretches from the circumference to the centre of the plant, to be the organ by which such a communication could be maintained; but the impermeability of this tissue to fluids opposes such an opinion. Malpighi thought the lateral communication to be made by an *anastomosis* of vessels; but in the vessels of plants no such mode of communication appears to exist. From the ascent of the sap in branches in which the vessels had been thus previously cut through, Mr Knight infers that this fluid does not rise in the vessels at all, but is conveyed through the cellular tissue. This opinion necessarily implies the permeability of this tissue by fluids, which, as we have shown, is contradicted by direct experiment, as well as by microscopical observation. Since, therefore, this lateral movement of the sap cannot be accomplished, either by simple percolation through the cells or vessels, or by direct anastomosis of the vessels with one another, no other known means of effecting it remain, but those of alternate deposition and absorption by the vessels into and from the cells. And if, as we have seen, the sap-vessels of plants deposit coloured fluids in the cells, which the capillary absorbents of parasitic plants are able to take up, there seems no reason for denying to the vascular productions, which have been supposed everywhere to spring from the perpendicular vessels, a like capacity of absorbing fluids from the adjacent cells. These fluids must, however, in all cases, have been deposited before they could be absorbed; and, by the alternate exercise of these functions, there is no difficulty in conceiving how a lateral movement of the sap might be accomplished in parts where, by the incision of the vessels, a stop was necessarily put to its perpendicular ascent.

Section V.

Of the Skin or Cuticular Texture, and its Appendages.

Art. I.—*Description and Structure of the Skin.*

The skin.

The skin, rind, cuticle, or epidermis, as it has been variously named, is the last of the common textures that remains to be described. It is the general envelope which invests all parts of the plant and all its productions, being equally common to the trunk and branches, the root, the leaves, the flowers, and the fruit; but in these different parts, and even in similar parts of different plants, it exhibits the greatest diversity of appearance and form.

Description.

In herbaceous plants, and in the young shoots of those which are arborescent, it resembles a thin membrane, but is generally thicker on the stem than on the roots or leaves. In some leaves, however, it is thick and dense, as is the case also in several fruits, and is thereby fitted to resist the effects of too rapid desiccation. On the upper surface of some leaves, on many fruits, and on roots, it is an entire membrane, destitute of any apertures

In young trees.

Common Textures.

or pores; but on many stems on the under surfaces of leaves, and sometimes on the upper, it is frequently furnished with numerous pores, often visible to the naked eye, and with other luminous points of smaller dimensions, which Du Hamel also regards as apertures. It is readily separable from the bark in recent and succulent parts, or after maceration in water; and in certain leaves it is very completely separated by a species of caterpillar, named by Reaumur the *miner*. It appears then to be a thin transparent membrane, often destitute of colour, and deriving, therefore, its appearance from the colour of the parts beneath; but both in leaves and flowers it is often itself coloured. It is frequently seen to extend in all its dimensions, in common with the parts it covers. Very often, too, as will be noticed hereafter, its surface is covered with hairs; and sometimes small follicles or utricles are met with, which exercise a glandular function.

In old trees.

The characters above enumerated belong chiefly to the cuticle in its young and succulent state. In perennial plants it commonly possesses others that are quite dissimilar. It is of a different colour not only on different trees, but on different parts of the same tree. It is white and shining on the trunk of the birch, and browner on the branches; greyish on the plum-tree; red and silvery on the cherry; green on the young branches of the peach; and ash-coloured on the larger branches. In these and many other instances it does not, says Du Hamel, merely participate in the colour of the body it covers, but contributes itself to give colour to the exterior bark; for when it is stripped off, the substance below has frequently a different colour. (*Phys. des Arbres*, tome i. p. 10.) By the gradual enlargement of the trunk it is stretched and dried, and at length loses its vitality, and, as well as the bark beneath, is variously cracked and broken. Before this happens, however, it often undergoes considerable extension in all its dimensions, enlarging in breadth, and stretching longitudinally over the young shoots. This expanded state is particularly remarkable in certain fruits, in which, when they enlarge slowly, the cuticle is extended without rupture to a very large size; but if the expansion be very rapid, as after considerable rains, the cuticle then gives way. In certain trees the cuticle is more susceptible of expansion than in others; and in very vigorous trees it breaks more slowly than in those whose growth is languishing, although these latter push forward more slowly than the former. (*Ibid.* p. 11.) In some vigorous trees of this description it altogether resists rupture; and in this state the tree is often said to be hide-bound or bark-bound.

Composed of layers.

In most instances the cuticle, when taken from young branches, appears to consist of a single layer; but on the branches of many species, says Du Hamel, after one plate or layer has been removed, another may be seen beneath, which resembles the former in its texture, but is much thinner and more green and succulent. From the birch-tree he has removed more than six layers, very thin and very distinct from each other, and is of opinion that more might still be separated. Sometimes the original cuticle seems to be entirely thrown off, and the exterior covering is formed by a portion of the cellular tissue of the bark. Grew thinks that this substitution takes place annually, the older skin being cast off, like the skin of an adder, by the generation of a new one beneath. (*Anat. of Plants*, p. 114.) Du Hamel describes also the existence of small leaflets or scales, which are continually detached from the cuticle of some trees; and these he considers to be as constantly replaced, by the formation of new ones beneath them.

Is regenerated.

Concerning the regeneration of the cuticle on parts from which it has been removed, Du Hamel observes, that when the wound is covered with waxed cloth, a new cuticle is promptly formed without any separation of a portion of the bark beneath. When the exterior portion of the bark is removed with the skin, the inner part of it is equally capable of regenerating a cuticle; but if the wound be not protected from the air, a certain degree of exfoliation first occurs, and, under the decayed parts, a new skin forms. Even where the bark of a cherry-tree was entirely removed from the trunk, he found that the wood was capable of regenerating a new bark and cuticle, if the parts were properly protected from the air. This cuticle did not originate from that which remained on the roots and branches, but was reproduced in isolated portions on different parts of the trunk; it continued, however, after the lapse of fifteen years, always different from that of the natural growth. In other instances, he adds, the cuticle does not seem to be regenerated at all. He remarks certain analogies to exist between the cuticle in some plants and in animals. In both, he adds, it seems in certain circumstances capable of great extension; in both it is easily regenerated, and that too in isolated portions, and not by continuity of organs, as is common in other instances; and in both, lastly, it is perpetually obliterated, and continually and imperceptibly renewed. (*Phys. des Arbres*, tome i. p. 11.)

Its

With respect to the nature of the cuticle, very different opinions have been advanced, and still continue to prevail. Are we to regard it as a peculiar organ, formed immediately by the proper exercise of the vegetative functions, or is it produced in a sort of secondary manner, by some changes induced on some previously constructed organ? Grew asserted it to be sometimes original, and in some instances produced out of the exterior layer of the cortical texture beneath it; and this first view of its origin seems to be generally supported by the descriptive character which has been assigned to it. Its co-existence with the first traces of vegetable organization, its continued growth and expansion, and its subsequent regeneration after removal, all seem to favour its primary and independent origin, which is also supported by investigations into its minute structure. Mirbel, however, and some other writers, after Hill, have regarded it, in all cases, not as an original membrane, but formed by the exterior sides of the common tissue of the plant; and where there is no separation of these sides in the form of a membrane, such plants are held to be destitute of a cuticle. (*Exposit. de l'Organisat. Végét.* p. 103.)

Its structure.

Another question relating to this organ is, whether it must be considered a simple membrane of uniform structure, or a compound of two distinct parts, like the true skin and the cuticle in animals. Grew seems to have regarded it as a simple body, but constructed both of vessels and cells, the cells being continuous with those of the bark. (*Anat. of Plants*, p. 62.) Such, too, seems to have been nearly the opinion of Malpighi, who describes it as constructed of horizontal ranges of cells, but often delineates reticulations of vessels as constituting a part of its structure. (*Anat. Plantar.* p. 2, 19.) In the birch, the plum, the cherry-tree, and others, Du Hamel declares the component fibres of the cuticle to possess a direction transverse to that of the trunk; but this is not general. In the birch-tree the fibres seemed to be placed parallel to each other, and to be connected together by lateral fibres; but he could see nothing of the vesicular structure of Malpighi and Grew, and therefore regards the structure of this texture to be altogether fibrous. (*Phys. des Arbres*, tome i. p. 8 and 9.) M. Desfontaines, on the other hand, describes it as a membrane resembling in ap-

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pearance a thin plate of parchment, and perforated by imperceptible pores, which give issue to the insensible transpiration. Its structure he regards as unknown, but considers it capable of regeneration. (*Mém. de l'Instit. Nat.* tome i. p. 481.)

Opinion of Kieser,

M. Kieser, who professes to have studied this texture with great attention, adopts nearly the opinion of Grew, pronouncing the cuticle to be constructed of a very fine cellular tissue, and of extremely minute vessels which run through its whole extent. These vessels form an exceedingly delicate and subtile net-work, the meshes of which possess very different forms, and their vessels terminate at the orifice of a pore. His observations were made on the cuticle of leaves. On the inferior surface of the leaf of *Amaryllis formosissima* (fig. 14, A, Plate XLI.), magnified 260 times, these vascular meshes of the cuticle have an elongated hexagonal form; and four of their vessels proceed always to terminate at the orifice of the little oblong aperture or pore situated at their junction. In *Canna Indica*, the vessels of the meshes on the lower part of the leaf, which thus terminate in the pores, are said to originate from a fasciculus of the spiral vessels that ramify through the leaf, as is represented at *a'* in fig. 14, B, Plate XLI.; and within the areas of the larger meshes a still finer net-work of vessels is seen. On the inferior surface of the leaf of a species of fern, the vessels of the cuticle, instead of forming meshes of different figures, exhibit the appearance of sinuous lines, which run in every direction through the cuticle. See fig. 15, Plate XLI. which represents the central part of the little adjoining leaf, magnified 130 times. These sinuous vessels often join, and, after making a half-circle, terminate by one extremity in the minute pores everywhere spread over the leaf, and by the other in the larger vascular fasciculi that ramify through it. At the letter *b'*, in this figure, the hexagonal cells that construct the parenchyma of the leaf are distinctly visible through the vascular sinuosities of the cuticle. It was by the examination of this leaf that M. Kieser was first enabled to discover the origin and termination of the vessels that construct the cuticle, having in all his previous investigations examined the cuticle in its separated state, after it was detached from its connection with the other organs; but the researches made on this leaf rendered every thing clear. (*Mém. sur l'Organisat. des Plantes*, p. 141–2.)

Krocker and others,

The vascular net-work of the cuticle, thus described by M. Kieser and others, had been regarded as a deception by M. Krocker, who considered these reticulated figures as no part of the real structure of the cuticle, but merely as the sides of the subjacent cells; in which opinion Sprengel, Link, Jurine, and Mirbel, concurred; but M. Kieser, in opposition to this opinion, maintains that, in the fern and other leaves, the real cellular structure of the parenchyma is seen entire through the vascular reticulations of the cuticle, with the meshes of which the sides of the subjacent cells do not anywhere coincide. He observes that these cells are commonly much smaller than the vascular meshes which cover them; and that the vessels of these meshes may be traced, as before remarked, to the larger fasciculi that construct the leaf. In the fern the vascular structure of the cuticle is the same on both sides of the leaf, but the superior side does not possess pores.

De Saussure.

A very different view of the structure of the cuticle was taken by the late celebrated M. de Saussure. He regarded it not as a simple, but a compound texture, consisting of a very delicate external pellicle or membrane, beneath which was placed a net-work of very fine vessels. The external membrane he describes as perforated by pores of unequal figure, between which he observed some opaque and tortuous filaments, disposed in a reticulated manner, each mesh being formed by six filaments, four of which terminated at each pore. To this arrangement of filaments he gave the name of cortical net-work, and regarded it as quite distinct from the cuticle that covered it. The meshes of this net-work differ much in size and figure in different leaves; and, when minutely examined, they are often seen to form junctions, but never to cross each other; whence he was led to regard them as vessels derived from those of the expanded petiole, and thus constituting a very fine vascular net-work. A similar structure was observed in the petals of the flower. (*Encyclop. Méthod.* tome i. p. 67.)

Opinion of De Candolle.

M. de Candolle considers the cuticle in certain parts to be a simple and proper membrane; in other parts to be formed by layers of cellular tissue. The cuticle of leaves, and probably of all annual shoots, appears to be formed of a layer of flattened cells, differing in form and in other conditions from those of the parenchyma of the leaf. It may be regarded in this state as a proper membrane. When stripped off and examined by the microscope, it exhibits small spaces, bounded by lines or rays, or a sort of net-work, the meshes of which have different figures in different plants. The lines, says he, appear in the form of single or double filaments, and may be considered hollow, and as forming a system of cuticular vessels which terminate in the pores. In more advanced age, and especially in the trunks of old trees, this primitive cuticle gradually changes its character, and finally disappears. It is then succeeded by a thicker membrane, which no longer exhibits the net-like figure of the former, and appears evidently to be formed by the exterior cells of the cellular tissue, which, by the combined effects of distention and desiccation, assume a membranous appearance, to which the term *epidermis* is properly applicable. This epidermis may be considered single when composed of one layer of cells, and double, triple, or multiple, when formed of two or more successive layers. It is thus that Ulloa, in describing a tree in Peru, speaks of having detached more than 150 epidermoidal layers, when he lost all patience in counting them, seeing that he had not then reached to half the thickness of the bark. A similar appearance is exhibited in the numerous layers that form the epidermis of the white birch, amounting sometimes to 15 or 18 in advanced age, and which ends by breaking into that cracked condition of the bark that presents only discontinuous portions of white epidermis on the remnants of its cellular envelope. At an early period the cuticle is most easily torn in a longitudinal direction, which is that of its growth; but at a later period, when the diametral growth has increased, the cells of the tissue are drawn out more in that direction, and therefore more readily break transversely than in length. (*Organog. Végét.* tome i. chap. 5.)

Art. II.—*Of the Pores of the Skin.*

Description of pores by Grew.

The pores of the cuticle, called sometimes cortical or miliary glands, sometimes exhaling pores, sometimes cortical pores, and more lately, by Link and De Candolle, *stomata*, were first noticed by Grew, who describes many orifices as existing on the leaves of different plants, which vary in size, number, shape, and position. In the white lily they are of an oval shape, of a white colour; and each is surrounded by a slender border. When viewed through a good glass they appear as if standing about one sixth or one eighth of an inch apart all over the leaf, but not arranged in any regular order. In the pine, also,

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they have an oval shape, but have no rising border, and are arranged in lines from one end of the leaf to the other. (*Anat. of Plants*, p. 153.) Hedwig considered the borders mentioned by Grew as produced by a ring of one or more vessels, which terminated in the pore. The number of pores he represents as exceedingly great. In the square of a line of the cuticle of a bulbous lily he reckoned 577 pores.

Description of pores by De Candolle.

The characters and position of these pores or stomata have been further examined by M. de Candolle on more than 600 plants. They occur most frequently on the leaves, occupying both surfaces in some herbs, and in trees chiefly the inferior surface. Stems in general have no pores, except, as in the *Gramineæ*, where they are succulent, and have the character of leaves; or where the plant is altogether destitute of leaves, as the Cactus. On the prominent lines or vessels of the leaves and stems no pores are to be seen, but only in the grooves or depressed surfaces of the parenchyma. They are never observed on the root, not even on bulbous roots, where the scales of the bulb are true leaves. The small leaflets called *stipulæ* and *bracteæ* sometimes have and sometimes have not pores. The *calices* of the flower in general have pores, but the petals have not. Pericarps of a foliaceous consistence have pores: when fleshy, they are destitute of them. The envelopes of the seed are destitute of pores, but they are found on all seminal leaves that rise above the ground. The lower tribes of vegetables, as the *fuci*, *musci*, *hepaticæ*, *fungi*, &c. are destitute of pores.

Influence of air on the pores;

The occurrence of pores in those plants where they are found seems to be much influenced by external circumstances. They are never met with but on vegetables, and those parts of vegetables that are exposed to the air; and therefore the internal surfaces of many leaves that embrace the stem are without pores, though on the external surfaces of the same leaves they are abundant. No plant that is completely aquatic, nor any part of it that is habitually under water, is provided with these organs; but the parts which rise above the water are furnished with them. In *ranunculus aquaticus* the leaves that are constantly under water are destitute of pores, while those that float on the surface are provided with them, but only on their superior face. Even leaves which do not naturally possess pores when under water, acquire them if they are made to grow in air; and land plants, on the contrary, when made to grow under water, may, by such treatment, be deprived of their pores. Thus, the leaf of green mint, when growing in air, possesses not fewer than 1800 pores on its lower surface; but if kept for a month under water, its leaves fall, and the new ones that succeed are destitute of pores.

of light on pores.

Light seems to be necessary also to the production of pores, for etiolated plants do not possess them. When grown by the light of lamps, the leaves possess a few pores; and, in all cases, the parts secluded from light and air are destitute of these organs, but acquire them if they are duly exposed. (*Mém. de l'Instit. Nat.* tome i. p. 351.)

Researches of Rudolphi.

This general account of the pores of plants is confirmed by the researches of M. Rudolphi. In most herbaceous plants he found the pores to occupy both sides of the leaf, but in trees only the inferior surface. They were not often met with on the parts of the flowers, or on fruits; they were never seen on roots, nor on the trunks of trees; nor ever on aquatic plants, except on such parts as were raised above the water. The lower tribes of vegetables seemed to be universally destitute of them; the leaves also of those plants that were covered thickly with hairs on both sides had no pores. The form of the pores was commonly oval or elliptical, but in a few instances square or rhomboidal. In size they very much varied in different plants, but in the same plant the size was uniform. The largest pores were seen on the leaf of the white lily, the smallest on that of the French bean. (Kieser's *Mém. sur l'Organisat. des Plantes*, p. 144.)

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Although the pores are generally dispersed over the parenchyma of leaves at nearly equal distances, yet where the vessels run parallel, they are disposed in one or more lines between them. Sometimes, again, they are collected into little clusters, as in the leaves of *crassula cordata*, where the roundish dots or points, visible by the naked eye, are clusters of pores or stomata. This appearance suggested to M. de Candolle the idea that the stomata might be the orifices of vessels, as each of the little points mentioned above is the termination of a fibre, which is itself a bundle of vessels. This idea is further strengthened by the fact that these pores are not found in plants that are destitute of vessels; and though he could never trace the continuity of a vessel with a pore, yet M. Comparetti assures us he has seen the vessels terminate in them. Mirbel, on the other hand, considers the pores to be the orifices of cells; and Kieser regards them as connected with the intercellular canals. (*Organog. Végét.* tome i. chap. 6.)

Pores, orifices of vessels.

Some have considered the pores as organs, by which the resinous or waxy matter found on certain leaves is exhaled; others, as organs for the absorption and transpiration of air or gas; and others, with more probability, as those by which moisture is thrown off by the leaf. In support of this last opinion, it may be stated that pores exist in all leafy parts that transpire, and are more numerous in membranous leaves that transpire most, than in fleshy leaves which transpire little. They are wanting altogether in aquatic leaves and in etiolated leaves; also in fleshy fruits, in roots, and in the petals of flowers, which do not transpire in any degree analogous to leaves. In darkness too, when transpiration ceases, the pores are closed; and they again open and transpire when light reappears, and especially in bright sunshine. It is always necessary to distinguish the evaporation, more or less great, that goes on through the tissue in all organs by day and by night, from the active transpiration which occurs in sunshine, but only in organs furnished with pores, and which seems to be executed by them.

Transpiration by pores.

Besides transpiration, M. de Candolle believes that, in certain cases, the pores may also serve for *absorption;* but this he considers to be rarely the case, and out of the natural course of vegetation; and that the experiments which favour this opinion may be explained by the hygroscopic powers of the vegetable tissue. He thinks the results obtained by Bonnet, who kept leaves a long time in life by laying their porous surfaces on water, may be explained by supposing this treatment to prevent decay by checking transpiration, rather than by promoting absorption. (*Organog. Végét.* tome i. p. 87.) This suggestion will not, however, explain the phenomena of an experiment continued for many years in the conservatories of the Royal Botanic Garden here, under the care of Mr Macnab. He has kept a species of fig (*ficus elastica*) for several years fastened against the wall, with its roots, stem, and branches entirely exposed to the air; and in that situation it has not only lived, but actually grown in every part, so as to have increased greatly in size, only by being thus kept in a warm and moist atmosphere, and occasionally sprinkled with water.

Absorption by pores.

In addition to these visible pores, it is probable, says M. de Candolle, that the surface of vegetables is furnished with others that are invisible, but so small that with the strongest microscopes we are unable to recognise them:

Invisible pore

their existence, therefore, can only be presumed from physiological phenomena. Thus, a part of a vegetable destitute of pores loses weight when exposed to the air, by the escape of the fluid it contained; or a portion of moss equally destitute of pores, if placed in water, speedily acquires additional weight. Whether these results are obtained through the medium of minute pores, or of unorganized apertures, such as are admitted to exist between the molecules of all matters,—and whether through the same pores or apertures a passage is afforded to gases or other fluids, or to the oily or waxy secretions that cover certain surfaces,—are questions, adds M. de Candolle, to which no answer can at present be given. (*Organog. Vég.* tome i. p. 88.)

Art. III.—*Of Hairs.*

From the surface of the cuticle, in many parts of herbaceous plants, and in the succulent parts of arborescent ones, hairs (*pili*) are seen to spring. They possess very different forms, and vary likewise greatly in texture. In a strict sense, they may be defined small filaments possessing considerable stiffness, which project from the surface, and stand out pretty erect. When they are very numerous, a little soft, and less erect, they take the name of *villi;* when still softer and less numerous they are termed down (*pubes*). Sometimes this down is composed of long hairs nearly resembling wool, at other times it approaches more to the character of cotton. When the hairs are stiff and ranged along the edge of a surface, like the lashes of the eye, they are named *cilia;* and if, with these characters, they are produced to a greater length, as in the beard or awn of wheat, they acquire the name of *barba* or *arista.* Sometimes they resemble the bristles of the hog, and are then called *setæ.* Many other varieties are enumerated by botanists, who further distinguish them by various names, according as they terminate in a single point, or are hooked, or forked, or branched, or feathered, &c. In some instances, instead of appearing like one continuous substance, they are composed of many joints, or are said to be articulated. In fig. 16 and 17, Plate XLI., we have copied from Du Hamel a few of the varieties, both of single and jointed hairs; but the forms they exhibit are so numerous and diversified, that we must refer to the writers on botany for minuter information. In some examples the point of the hair is terminated by a small rounded globulet, and sometimes by a fine filament, that seems to proceed out of the hair.

Some writers distinguish hairs into two general classes,—the glandular and lymphatic. In the former class, the hair or filament is sometimes the excretory duct of the small gland situated at its base; and in other instances, as in the chick-pea, the glandular or secreting organ is seated at the extremity of the hair. The lymphatic class embraces a much greater variety of hairs, which differ widely from each other in consistence, direction, and form. They spring only from the parts of plants which are exposed to the air, and are not found, therefore, on the parts concealed below the earth or in water: they are also rare on plants that grow in the shade, are wanting altogether in *etiolated* plants, and are most abundant, in general, on plants that grow in warm places, and are well exposed to solar light. With respect to their seat or origin, as compared with that of the pores, although, says M. de Candolle, these two kinds of organs appear sometimes mingled, yet each has a determined place; for the pores are seated on the cellular or parenchymatous parts, while the lymphatic hairs constantly spring from the vascular or ligneous parts. Yet the hairs, he adds, are almost always placed on the same surface as the pores; and hence the superior surface of the leaf, which is commonly destitute of pores, has in general but few or no hairs. The pores, as before stated, seem to be the true organs of transpiration; and the various kinds of hairs serve to protect the plant against the excess of solar light, against variations of temperature, against humidity, or sometimes against insects. (*Organog. Vég.* tome i. chap. 10.) Hairs, also, of various kinds are met with on the different parts of the flower. These often have the colour of the petals or other parts on which they grow, and are distinguishable from the true lymphatic hairs, though sometimes associated with them on the same organ.

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Structure.

With regard to the structure of these minute bodies, little that is satisfactory can be said. They seem to originate either directly from the cuticle or from the cortical texture beneath it; but not often from the ligneous texture, except in those instances where they are very long and rigid, as in the awns of wheat. Du Hamel observes that almost all of them are implanted on small bodies, similar to the bulbs which give origin to the hairs of animals. (*Phys. des Arbres,* tome i. p. 183.) They commonly resemble simple filaments, but often appear like elongated cells threaded on one another, and, instead of terminating in a sharp point, end in a small papilla or utricle, which yields in many instances a viscid or oily matter, or sometimes a coloured liquor, which has led many to regard them as exercising a glandular function.

Hairs of chick-pea.

One species of these supposed glandular organs has been more particularly examined, and their fluid analyzed, by M. Deyeux, who gives the following account of it. Soon after the seeds of the chick-pea (*cicer arietinum*) are sown, its first leaves are seen to be covered with hairs, at the extremity of each of which is a transparent globule, about the size of a small pin-head, consisting of a fluid matter. It abounds most in mid-day, when the air is warm and dry, and is scarcely perceptible at night, or when the air is cold and moist; after rain, indeed, it does not again appear for two or three days. When these fluid globules were removed in a dry day by blotting-paper, they soon re-appeared; they were acid to the taste, reddened litmus paper, and caused an effervescence in carbonate of potash when brought in contact with it. He regarded them as composed of oxalic acid, the properties of which they precisely resembled. (*Mém. de l'Instit. Nat.* tome i. p. 157.)

Art. IV.—*Of Prickles and Thorns.*

Definition;

It is not easy to discriminate between some of the harder species of hairs, described in the former article, and those to which the appellation of prickles (*aculei*) has been assigned. They are defined by Du Hamel to be excrescences, often hard, and always terminated by a sharp point, which are developed with the other productions of plants, but are not inclosed in particular buds; so that they may for the most part be regarded as hard and solid hairs.

position;

They spring equally from the stem, the branches, the petioles of the leaves, and also from the leaves themselves in various plants; and in the chesnut and some others they are seen to cover the fruit. They are frequently straight, but in the rose and many others are curved at the point, as in fig. 18, Plate XLI.; and, according to Malpighi, possess sometimes in this plant a little head, which yields a viscid fluid.

Structure.

Regarding their structure, Grew remarked that they were connected only with the skin or the bark, and he therefore named them *cortical,* to distinguish them from thorns properly so called, such as those of the hawthorn,

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which spring from the wood, and which he denominates *ligneous*. These latter, he adds, always ascend, while the cortical thorns commonly point downwards. (*Anat. of Plants*, p. 33.) In proof of their origin from the bark, Du Hamel remarks, that if, after maceration in boiling water, the bark of such plants be stripped off, all the prickles come away with it, and leave not the smallest impression on the wood, nor even on the more interior layers of the bark itself. When a section also is made of the branch and prickle, as in fig. 18, Plate XLI., the wood *y* and the pith *z* are both seen to have no connection with the prickle, but the inner layer *x* of the bark is interposed between the base of the prickle and the wood. The prickle does not, however, spring from the skin, for it is formed of many layers like the bark. As the parts become more solid, it is less freely supplied with juice, and therefore hardens and turns brown. (*Phys. des Arbres*, tome i. p. 188.)

Prickle of the nettle.

In the nettle (*urtica dioica*), Malpighi states, that beside the common prickles on the leaves, there are among them others of a different description. They possess more of a ligneous character, are hollow internally, and contain a juice which, when it gains admission beneath the skin, excites itching and tumour. (*Anat. Plantar.* p. 137.) Dr Hooke had previously given a much more minute account of the sting of this plant. Almost every part of it, says he, is covered with prickles like sharp needles. Each prickle consists of two parts, very different in shape and quality from one another; one is shaped much like a round bodkin, is very hard and stiff, exceedingly transparent and clear, and hollow from top to bottom. When this bodkin is thrust into the skin, it does not at all bend; but a certain liquor is then seen to move up and down in it, rising towards the top, when the point is pressed down on the base. This base is formed by a little bag, is more pliable than the bodkin part, and within it is a cellular structure, which contains a thin transparent liquor (see fig. 19, Plate XLI.): it is this liquor that rises in the tube, and, being deposited beneath the skin after it is punctured, excites the irritation that succeeds. (*Micrographia*, p. 142.)

The true thorn (*spina*) derives its origin, as Grew remarked, from the ligneous part of the plant, and in some plants is produced from the degeneration of some other organ, as of the leaf, or even the branch itself: we shall therefore defer the further consideration of its structure, until we come to treat of that of the branch.

Section V.

Of the Glands of Vegetables.

Ambiguity of the term *gland*, in Animal Anatomy,

Perhaps in the whole science of anatomy there is no word that has been employed with such latitude of signification, and is therefore exposed to so much ambiguity, as the term *gland*. In animal anatomy it was doubtless used at first to denominate certain organs, from the external resemblance which they bore to certain fruits or seeds; and in that sense it is still employed on several occasions. Afterwards it was understood to signify not so much the external form as the internal organization, and was considered to express a certain structure, by which alone the function of secretion could be exercised; but it is well observed by Dr Thomson, in his valuable work on Inflammation, that "the definition of a secreting glandular part must be taken from its function, and not from its structure; for nothing can be more various than the internal structure of those organs that are denominated glandular secreting organs: they consist sometimes of convoluted vessels, sometimes of follicles or small hollow bags, and sometimes of transparent membranes, in which neither convoluted vessels nor mucous follicles can be perceived." (*Lectures on Inflammation*, p. 318.) Besides these more simple structures, it is well known that most of the internal *viscera* are likewise denominated glands, though differing in all their characters from those just mentioned.

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The ambiguity which thus prevails in animal anatomy, in relation to the use of the term gland, has been increased tenfold in the applications that have been made of it to the organs of vegetables. It is justly observed by M. de Candolle, in reference to this subject, that the numerous approximations in structure between vegetables and animals have often promoted our researches into the former, but have sometimes led physiologists astray, and introduced into the language of botany many inexact expressions. In animal anatomy the term gland is understood to express some organ that exercises a secretory function; but in vegetable anatomy this term has often been applied to bodies that are not known to be real secretory organs. Thus the cells of the cellular tissue, which frequently contain resinous or oily matter, have been sometimes named *cellular glands;* the little globulets or utricles at the extremities of the hairs on the edges of leaves, *utricular glands;* the small organs formed by the pores on the leaf, *cortical* or miliary *glands;* certain fleshy tubercles on the leaves, *urceolar glands;* and the little scales that cover the fructification in ferns, *scaliform glands*. The *nectarium* of the flower commonly contains a sweet juice, and is therefore deemed a gland; but Linnæus, with his usual disregard both of the structure and function of organs, considers as a nectary, not only the body which may secrete, but any other that may serve as a receptacle of the secretion; and indeed is said to comprehend under this term all those bodies which have no resemblance to the other parts of the flower, in whatever variety of form they may appear, or whatever purpose they may serve. (Willdenow's *Principles of Botany*, p. 87.) In some other instances the term gland has been used, not to express the secreting organ itself, nor even the receptacle of the secretion, but the solid excreted matter on the surface of certain leaves; and others consider hairs, and every other protuberance that projects from the surface, and contains a fluid different from the common sap, as entitled to the distinctive appellation of gland.

Difficulty in defining glands.

Amid such diversity of opinion concerning the structure, position, and function of these minute organs, and such vagueness in the methods employed to characterize them, it is extremely difficult to define their true nature, or declare the principle on which this definition should proceed. The mere existence of a fluid, distinct from the common sap in any organ, cannot be considered as bestowing on it the title of gland, otherwise the greater portion of some plants would come to be regarded as glandular: those varieties of structure which exercise no secretory function may also be excluded from the list of glands; and so likewise the hairs of plants, though containing peculiar fluids, may be excluded, since these peculiarities appear to arise frequently from circumstances foreign to the action of the organ itself; and even if they do not, some specific variation of the general name they bear is preferable to the employment of so ambiguous a word as gland. But where any organ is distinct from the common textures of the vegetable, and by the peculiarity of its structure is fitted to produce those changes on the vegetable fluids which we name secretion, it may be deemed a secreting organ. This secretory function, however, may sometimes be exercised, as in animal bodies, by membranous surfaces, and sometimes by small isolated bodies, to which, perhaps, may properly belong the denomination of glands.

But even though this method of defining glands were

lopted, it still is a matter of no small difficulty to distin-
uish their species by appropriate appellations. In ani-
al anatomy no settled rule obtains; but the name of the
and is assigned from some accidental circumstance of
tuation, figure, use, &c. In vegetable anatomy the bo-
nist, regarding glands only as aiding the discrimination
species, refers commonly to their situation, and speaks
foliaceous, stipular, or petiolar glands, according as
ey happen to be seated on the leaves, the stipules, or the
tioles. The anatomist imposes names according to their
rms, as they chance most to resemble a globule, an
ricle, or some other figure; and the physiologist is
iefly directed by ideas which indicate their functions,
stinguishing them into mucous, oily, resinous, or necta-
ferous glands, according to the nature of the fluid they
rnish. Of these different modes, that which proceeds
the apparent form, where it can be discovered, seems
e most precise; but as this cannot always be accom-
ished, the situation of the organ, or the nature of the
creted fluid, must occasionally be had recourse to.

Of these bodies it is to be remarked that they differ in
e respect from most of the corresponding organs in ani-
als, almost all of them being seated on the *external parts*
the plant, like several of the more simple glandular bo-
es in animals. This arises from the greater simplicity
vegetable organization, particularly as it regards the
sorbent system, the mode of growth, and the perma-
nce of the organs produced; whence it happens that
e living parts of aged perennial plants are situated only
or near the surface; and it is only in such parts that
tive secretory functions can have place. Hence it is on
cculent stems, on leaves, flowers, and fruits, during the
tive state of vegetation, that the glandular functions of
getables must be exercised; and which parts, therefore,
e the appropriate seat of glands.

In some leaves a secretory function extends over a
eat part of the surface, as in some species of *Cistus*, of
gar-maple, of larch, and others enumerated by Du Ha-
el, on which various collections of saccharine, gummy, and resinous matter are found. (*Phys. des Arbres*, tome i. p. 183.) On the leaves of sage, Hooke mentions the occurrence of an infinite number of round balls resembling pearls, and which, says he, are nothing but a gummy exudation. (*Micrographia*, p. 142.) M. Guettard has described not fewer than seven species of glandular bodies on the leaves of different plants, to which he assigned names, chiefly from the appearance of their form; these are the *miliary*, the *vesicular*, the *squamous*, the *globular*, the *lenticular*, the *utricular*, and the *urceolar* glands. Of these reputed species, those called miliary are no longer held to be glands, but cuticular pores; and the squamous species is found to be identical with the thin scale that covers the fructification of ferns. Others add to this list the organ called nectary; but the very vague notions entertained of its nature and use altogether preclude the possibility of assigning to it any precise anatomical character.

Common Textures.

according to Guettard,

Other writers have proposed to reduce all the bodies called glands to two classes, the *cellular* and the *vascular*, according as they conceive them to be formed of cellular tissue simply, or of this tissue and vessels combined. But such an arrangement would lead us, in some instances, to confound the mere receptacles of secreted fluids with the organs that secrete them,—would bestow a secretory function on organs considered by these writers to be *non-vascular*,—and convert the entire cellular tissue of the plant into a simple glandular body. The glands of plants may indeed possess the form and size of cells; but they are not, like cells, close cavities; they resemble more the follicles and mucous glands of the animal system, and, from the nature of their function, must always be regarded as vascular.

and others.

Of organs so minute, and so very imperfectly known and characterized, nothing can be attempted in the way of anatomical demonstration. This, however, is the less to be regretted, as the glandular system in plants appears in general to be of much less consequence in the vegetable than it is in the animal economy.

PART II.

THE ANATOMY OF THE INDIVIDUAL MEMBERS AND ORGANS OF VEGETABLES.

In the preceding Part we have described, in general,
e nature of the elementary organs and common textures
at compose the entire plant; and we come now to the
cond division of our subject, viz. the description of in-
vidual members and organs. Following the method of
rew, we shall first exhibit the anatomy of the seed, and
e changes of form and structure displayed in its evolu-
on. We shall next treat of the mature plant, and exhibit
ews of the more remarkable varieties of structure observ-
l in its several members, as the trunk, the branch, and the
ot. The organs that originate from these members, as
ds, leaves, flowers, and fruits, will then be duly noticed;
d we shall terminate our descriptions by a brief exhibi-
on of the formation and structure of the vegetable *ovum*
its progress towards the state of the perfect seed.

The limits within which, in a work like the present,
e are necessarily circumscribed, will render our view of
ese individual structures, when compared with the im-
ense variety that obtains in nature, exceedingly imper-
ct; but our purpose will be accomplished if we succeed
exhibiting a correct and tolerably comprehensive out-
ne of the great features of vegetable organization, as
ey are displayed in the individual parts and organs of
e more perfect plants.

CHAP. I.

THE ANATOMY OF SEEDS.

SECTION I.

Of the Structure of Seeds in general.

ART. I.—*Of the External Characters and Component Parts of Seeds.*

The seed or egg of vegetables (*semen vel ovum*) is formed at the base of the pistil of the flower, in an organ called the ovary (*ovarium*), hereafter to be described. This organ takes the name of pericarp when the seed is mature, and is then said to be formed of three parts, enveloping each other. The outer membrane has been called epicarp, and the inner one endocarp, between which the thicker portion, called sarcocarp, is placed. In fleshy fruits, as the peach and apple, the sarcocarp is very thick, and contains the matter which nourishes the seed. Interiorly, the pericarp is either simple or separated by one or more partitions into cells, which contain the seeds. The seeds accordingly communicate with or are attached to the pericarp, at the point of the seed named *hilum*, from which point the ves-

The seed: its attachment to the ovary.

Of the Seed. sels pass through the inner membrane of the pericarp, and are continued to its fleshy portion, which supplies the materials for its growth. These vessels form the umbilical cord (*funiculus umbilicalis*); but sometimes, it is said, this cord, from its extreme tenuity, or implication with other organs, cannot be discovered. When the seed has attained to maturity, the umbilical cord dries up and breaks, and the pericarp opens in various ways in different plants, to permit the escape of the seed.

Numbers of seeds: The seeds of different plants exhibit the greatest diversity in number, size, and figure. Sometimes they are few, in other instances very numerous. In one plant of white poppy Grew reckoned 32,000 seeds, and on the spike of a species of *typha* he numbered 40,176 seeds; so that, upon the three spikes which one stalk of this plant bears, there are every year produced more than 120,000 seeds. (*Anat. of Plants*, p. 198.) In figure the varieties in seeds are so numerous as to baffle description; and, with respect to size, many are so minute as not to be visible to the naked eye, and others so large as to reach several pounds in weight.

their size and figure.

Umbilicus of the seed. The part at which the seed has separated from the ovary is indicated by a small mark or scar, called by Malpighi *fenestra*, by Linnæus *hilum*, and by Gærtner *umbilicus*. In some seeds this scar is of considerable extent, and is the only mark that is visible; in other instances there seems to be present a *foramen* in addition to the scar. All seeds, says Grew, have their outer coats open, either by a particular aperture, or by the breaking off of the cord, or by the entrance of the cord into the substance of the seed, as in those which have a shelly or stony covering. In the bean this aperture is placed on the side, in the chesnut on the top, in the gourd at the bottom; and in each case the point of the radicle is opposed to the aperture, and first pushes forth through it. (*Anat. of Plants*, book i.) In many seeds, however, the radicle is not thus opposed to the umbilicus, but, according to Gærtner, is variously placed with regard to it; and in the seeds of the apple and pear, Malpighi considers no proper umbilical aperture to exist, but only an *hiatus* to be formed by the relaxation of the tunics, through which the radicle makes its way. (*Anat. Plantar.* p. 9.)

Varieties in its form. There can be no doubt that, in every case, a connection subsisted between the seed and the ovary during the formation of the seed; but this, in different examples, may have much varied. In all cases an umbilical cord must have existed, and appears, in many examples, from inspection of mature seeds, to have been the only visible medium of connection. In the bean, however, besides the umbilical cord there are marks of a connection also between the coats of the seed and those of the ovary that contained it, so that the scar or cicatrix, in that and similar cases, is distinct from the umbilical aperture. The scar is the mark left by the separation of the tunics continued from the ovary; the foramen is the aperture produced by the separation of the umbilical cord. It will be afterwards stated that the outer coat of the seed appears always to have originated from the inner coat of the ovary, so that it forms a sheath about the umbilical cord. If, therefore, as in the bean, these coats are thick, and the umbilical cord short, then traces of the separation, both of the coats and of the cord, will remain on the seed; if, on the other hand, the coats are thin, and the cord more elongated, this latter will be closely invested by the former, and the umbilical scar will present the appearance only of a simple aperture, as is common to many seeds.

Opinion of M. Turpin. A late writer, M. Turpin, regards the umbilical scar as consisting of three parts, viz. the proper cicatrix itself, in the centre of which he describes an aperture through which the nutrient vessels passed to the embryo; and near to it another smaller aperture, through which he believes the spermatic vessels to have passed. The former he calls the *omphalode*, the latter the *micropyle*, and declares that he observed it in more than 1200 seeds. (*An. du Mus. d'Hist. Nat.* tome vii. p. 199.)

Of the S.

From the situation of the umbilicus, the several parts or regions of the seed have been defined. They are six in number. The part where the umbilicus itself is placed is termed the *basis*, and the point at the opposite extremity the *vertex* of the seed; the upper or back part is named the *dorsum* or back, and the part opposite to it the *venter* or belly; while the two lateral portions are called the sides (*latera*). The point where the umbilical cord is inserted into the inner coat has been named the *internal umbilicus*. This point usually coincides with that of the external, but, from a change in the relative position of the parts during their formation, this coincidence is not always to be observed. (Gærtner *de Fructibus et Seminibus Plantarum*, vol. i.)

Regions of the seed. Internal umbilicus.

When examined in its mature state, the seed is found to be composed of certain coats or tunics, which inclose a kernel or *nucleus*, that also consists of several distinct parts. At an early period of growth, while the parts are still green and succulent, two coats are easily distinguished, as in the transverse section of the bean (fig. 30, Plate XXXVIII.), in which the inner coat *a* appears much thicker than the outer, and the radicle *b* is seen rising through it.

Coats of the seed.

When these coats are stripped off, the parts which form the *nucleus* are brought into view. They consist, in the bean and most other seeds, of two distinct parts, the lobes or cotyledons, as they have been called, and the radicle and plume. These several parts can be seen only by separating the two lobes from each other, as is done in fig. 31, where the letters *c c* denote the cotyledons, *d* the radicle, and *e* the plume. Such seeds as have thus two cotyledons are named *dicotyledonous*.

Its nucleus, in dicotyledons,

In many seeds, however, the part called cotyledon is single, and often bears but a small proportion to the entire bulk of the seed. Seeds which have thus but one cotyledon are named MONOCOTYLEDONS; and to this division the seeds of wheat, of barley, and of all the grasses belong.

in monocotyledons.

Many of the lower tribes of plants are entirely destitute of a cotyledon, and are called ACOTYLEDONS. Some writers assert that some seeds have more than two cotyledons, and such seeds they have denominated POLYCOTYLEDONS; but others, again, choose to consider these appearances not as distinct cotyledons, but only as deep fissures, or divisions into two primary lobes; and hence conclude, that all seeds having a cotyledon may be classed under the two divisions of mono and di-cotyledons.

Acotyledons. Polycotyledons.

ART. II.—*Description and Structure of the Coats of Seeds.*

Having given this general view of the several parts that compose the seed, we proceed now to a more particular description of their structure; and, as the tunics come first into view, we shall begin with them. These tunics, in some seeds, are two; in others, three in number. By Grew they were named coats or covers; by Malpighi, *secundinæ*; and by Gærtner, *testa* and *membrana interna*. We shall speak of them in the familiar terms of the outer, the inner, and the middle coats or tunics.

Number of tunics.

The outer coat or *testa* of Gærtner is described as a constant and essential part of the seed. It existed before the period of fecundation, and is sometimes the only apparent

Outer

covering possessed by the mature seed. Some seeds have indeed been considered to possess no tunic whatever, and have therefore, says Gærtner, been named *acocca;* but in such seeds there existed a coat before they arrived at maturity, and its apparent absence has been inferred from its extreme thinness, or its condensation with the sides of the surrounding ovary. (*De Fructib. et Seminib. Plantar.* vol. i. p. 132.) A distinguished botanist, however, Mr Brown, is said to have discovered two examples of seeds absolutely destitute of a covering, from their first appearance to their state of maturity. (Thomson's *Annals of Philosophy*, vol. i. p. 310.)

In different seeds this tunic possesses a very different structure, being in some thin and membranous; in others of a spongy or fleshy nature; and in others, again, it approaches to the consistence of leather or bone. But how various soever in this respect, it is always an entire tunic, and has no aperture but that of the umbilical foramen. Its colour is usually deeper than that of the other parts of the seed; and in this particular it presents every possible variety. It has rarely any connection with the nucleus, except in some monocotyledons. (Gærtner, vol. i. cap. 9.) With regard to its origin, Malpighi describes it, in its earliest state in the almond, as derived from the ovary itself, being composed of reticulated vessels, which spring from the surrounding organ. In other instances it is thicker, and is distinctly seen to be cellular as well as vascular; and in the bean and pea, little tubes are said by Malpighi to originate from the cells, and terminate by open mouths on the surface. (*Anat. Plantar.* p. 9.)

Both Malpighi and Grew discovered, in some instances, a very thin membrane to cover this outer coat, which, according to Gærtner, may be found in most seeds, if the parts be scrupulously examined. Its structure is sometimes membranous, often downy, and sometimes mucilaginous; it possesses occasionally considerable thickness, and at other times is a mere pellicle, and thence has been named *pellicula.* It covers the whole seed, and does not ever separate spontaneously from it. (Gærtner *de Fructib.* &c. vol. i. cap. 9.)

Besides this pellicle, another fine tunic named *arillus* is sometimes observed on the surface of the seed, as in the seed of euphorbia. It originates from the umbilical cord at the base, and extends more or less completely over the body of the seed. Its structure is very various, being sometimes soft and pulpy, at others thin and membranous, and in others forming a husky covering. It forms, in some instances, only a loose and partial covering; and in others it invests the seed so closely and completely, that it can scarcely be distinguished from the outer coat itself. Both in figure and colour it often varies greatly, but, like the pellicle before described, it is regarded rather as an accessory than a necessary integument.

To the exterior coat of the seed various appendages are sometimes attached, as down, wings, spines, hooks, all designed either as a defence to seeds or to facilitate their dispersion. They are distinguished and described by the botanist, but are in general of too fine a texture to be made the subject of anatomical demonstration.

The inner tunic (*membrana interna* of Gærtner) is a common but not constant part of the mature seed. It appears sometimes to be wanting, when in reality it is present. During the formation of the seed it is frequently so extenuated, or coalesces so completely with the outer coat, that it cannot be properly distinguished. In its earlier state it is represented by Grew as a very spongy and succulent body, and as thick and bulky as one of the lobes itself; but it dries and shrinks up as the seed approaches maturity, so that it is sometimes scarcely discernible. (*Anat. of Plants*, p. 47.) In the seeds of most plants it closely invests the nucleus, but is easily separable from the outer tunic. In those of the *Gramineæ*, where the bulk of the seed consists almost entirely of unorganized matter, no separation of this tunic from the contained parts occurs; but its inner surface is formed into a cellular tissue, in the cells of which the nutrient matter is lodged. In other instances the inner surface is prolonged into processes, which penetrate into the nucleus, and intersect it in various directions.

Of the Seed.

Its origin and structure.

This inner tunic does not, like the former, exist before fecundation, but is formed subsequently to it. It is composed of vessels and cellular tissue. The cells are commonly larger than those of the outer coat. It has no aperture, says Gærtner, not even an umbilical one; but resembles a shut sac, over whose external surface the umbilical vessels creep, and open, in an insensible manner, within its cavity. (*De Fructib.* &c. cap. 9.) The distribution of the vessels throughout the whole of this coat Grew compares to that in the leaf.

Inmost or third coat

Beneath this inner tunic Grew describes another fine membrane, which immediately invests the lobes or cotyledons of the seed. In the bean it is exquisitely thin, and so firmly continuous with the lobes, that some dexterity is required to accomplish its separation. It is spread not only over the convex surface of the lobes, but also over the inner or flat surfaces, where they are contiguous, extending likewise over the radicle and plume, and so over the whole nucleus of the seed. It does not, like the other tunics, cease to grow in germination, but is augmented and grows with the organic parts. (*Anat. of Plants*, b. i. ch. 1.) This tunic may be regarded either as a covering to the nucleus, or as an actual portion of it, as Gærtner, who speaks only of two coats, seems to have considered it. It appears, however, more proper to regard it as the inmost coat, and thus to conclude, with Grew, that the covers in most seeds are three. (*Ibid.* b. iv. ch. 3.) The coat last described must in that case be considered as the middle tunic, being situated between the outer one and that which is continuous with the nucleus. In many seeds, however, only two coats are distinctly visible.

Use of the coats.

The foregoing tunics not only contain the nutrient matter, and afford a mechanical protection to the organic parts, but seem fitted also, by their chemical constitution, to resist the operation of agents that might otherwise effect their decomposition, and that of the nucleus they inclose. From the experiments of Fourcroy and Vauquelin, on the tunics of certain seeds that grow in marshy situations, it appears that, besides the usual ingredients of vegetable substances, there exists in them a compound, formed by a combination of tannin with a peculiar matter of an animal nature, in union with a vegetable acid. This combination of tannin with the matter just mentioned renders these tunics insoluble in water, and enables them to resist putrefaction, although buried for long periods in the moist earth. The tunics of those seeds which do not possess this chemical constitution may, it is added, by their ligneous or horny texture, or by the oily matter with which they are penetrated, present similar obstacles to the action of decomposing agents. (*An. du Mus. d'Hist. Nat.* tome xv. p. 77.)

Art. III.—*Description and Structure of the Nucleus of the Seed.*

Nucleus; its several parts.

We proceed next to describe the parts contained within the above-mentioned coats or tunics, and which constitute the *nucleus* of the seed. These parts, as already observed, consist of the radicle, the plume, and cotyledons, together, in most instances, with the nutrient mat-

Of the Seed.

ter destined to support their future growth. The three former bodies are completely organized, but the nutrient matter is wholly inorganic, varies greatly in quantity and proportion in different seeds, and is very variously situated with respect to the organized parts.

These parts, which in the progress of their evolution give birth to the new vegetable, derive their visible origin from a medullary point, that succeeds to the act of fecundation. By some these organized parts have been called the *corculum*, by others *embryo*, by others *fœtus*, and by others *plantula seminalis*. The primary point or particle from which they originate may with propriety, says Gærtner, be termed *corculum*, since it is the source and seat of vegetable life, and from it the whole vascular system of the embryo proceeds. In some instances this corculum increases so little as to be scarcely visible even in the mature seed, or exhibits only a palish spot, which has been termed *cicatricula;* in others it forms a roundish radicle, whose apex is free and rises above the nucleus, but whose base is firmly connected with it; in others, again, the corculum is still more disengaged, enlarging at each extremity, and producing at one end the radicle, and separating at the other into the two lobes called cotyledons, between which the first bud or plume of the future plant is situated. From this varying growth of the corculum, an embryo, more or less perfect, is produced. When the embryo presents only a mere germinating point, it is styled *imperfect;* when it exhibits a simple radicle, it is deemed *incomplete;* when it possesses both radicle and cotyledon, it is considered *perfect;* and when it consists of radicle, cotyledon, and plume, it is pronounced *complete*. (Gærtner *de Fructib.* &c. vol. i. cap. 13.)

Corculum.

Embryo.

Description of the embryo.

In the mature seeds of the less perfect plants the embryo is altogether invisible until after germination, and even in many other instances its characters cannot be accurately traced. Its general figure is determined by that of the radicle and cotyledons, and is exceedingly various in different seeds. In size it ranges from a minute point to that of a body of considerable magnitude. In consistence it is almost always soft and herbaceous, but its radicle possesses sometimes a ligneous hardness. No seed contains more than one embryo, except in cases of *superfœtation*, of which Gærtner saw one instance in *Pinus Cembra*, a seed of which contained two embryos within one and the same cavity. (*De Fructib.* &c. vol. i. p. 168.) Malpighi also records a similar occurrence in a seed of *Prunus Armeniaca;* and the seeds of some *Gramineæ*, as will afterwards be shown, are capable of evolving an indefinite number of embryos. Every *complete* embryo is said to consist of three distinct parts beside cotyledons. These are the radicle, the stem, and the plume.

Its radicle.

The radicle (*radicula*), called *rostellum* by Linnæus, is the most constant part of the embryo, being found in some seeds in which no other trace of that body can be discovered. In the seeds, however, of the less perfect plants, and even in those of some monocotyledons, no radicle is visible antecedent to germination. In some rare instances among dicotyledons, as in *nelumbo nucifera*, no radicle exists; but in germination the stem first rises upward, and afterwards emits rootlets from its sides. (*An. du Mus. d'Hist. Nat.* tome xiii.)

The size of the radicle is very various, and so also is its figure, being either conical, cylindrical, filiform, or tubercular, &c. It always, says Gærtner, occurs solitary, except in *secale*, *triticum*, and *hordeum*, to which alone, of all known seeds, three, four, or six radicles, properly formed, and distinct from each other, are furnished to each embryo. (*De Fructib.* &c. p. 169.) This plurality of radicles in the *cerealia* had before been remarked by Malpighi. M. du Hamel describes the seed of misletoe (*viscum album*) as emitting numerous radicles like those of wheat. (*Mém. de l'Acad. des Sciences*, 1740.)

Of the

Its stem.

The stem (*scapus*) of the embryo is a continuation of the radicle, and connects it with the plume. It is frequently wanting altogether, nor, when it is present, can we fix precisely on the point where the radicle ends and the stem begins. What is called stem descends frequently into the earth, and becomes a true root; so that every part of the embryo situated beneath the cotyledons might without impropriety be denominated radicle. The place of junction between the radicle and stem was called by Grew the *coarcture*, from its presenting often an evident degree of contraction; but M. Bonnet and others have given it the more appropriate name of the neck (*collum*) of the seed.

The plume (*plumula*) is the first bud of the new plant. In seeds that possess but one cotyledon it is very generally wanting; and even in those which have two cotyledons it is not unfrequently absent, or is at least concealed within the stem. In most of the latter sort of seeds, however, the plume is met with. It is placed on the top of the stem or radicle, and lies between the cotyledons, by which it is variously compressed and folded on itself. In the greater number of seeds it is not entire, but at its free end is divided into several pieces, all closely couched together, like feathers in a bunch, and thence called the *plume* by Grew. In different seeds its several little leaves vary much in figure, size, and number. The structure both of the radicle and plume will be most advantageously displayed in connection with that of the cotyledons.

The

Of the organized parts of the seed, the organs called by Grew *lobes* or *dissimilar leaves*, by Malpighi *seminal leaves* or cotyledons, remain to be described. The cotyledons derive their origin from the embryo itself, of which they constitute a part. The seeds, however, of some tribes of vegetables, as before remarked, are held not to possess these organs; and in many others the mass of nutrient matter has been confounded with them. When present they are either simple or divided. The simple cotyledon is formed by the mere extension of the corculum, and is in truth scarcely distinguishable from the stem itself. The double or conjugate cotyledons are produced by fissures, which usually divide that part of the embryo that is opposed to the radicle into two or more equal portions or lobes. These lobes have at first the appearance of mere tubercles, and in many seeds they retain this form unchanged; but in others they gradually expand into *lamellæ* or plates, which augment in size, and finally exhibit the proper form of cotyledons. This form is very various, as likewise is the size of these organs. Sometimes they are so small as to be scarcely visible, and sometimes so large as to form the chief portion of the seed. Their substance is either thin, or thick, or turgid. Their colour is commonly white, but sometimes yellowish, purple, or green, the colour into which they all pass during germination.

Concerning the structure of the cotyledons, it may be said that, in the more perfectly developed seeds, they are formed of cellular tissue, through which vessels are everywhere distributed; and, as we have already remarked, they are everywhere covered by a fine pellicle or coat, which prevents alike their adherence to the plume and to each other. This cellular structure of the cotyledon is well displayed by Grew (fig. 32, Plate XXXVIII.) in a slice of the cotyledon of the recent bean; and it is easily seen in a thin slice of almost any mature seed, if it be held

Of the Seed. against the light after it has been soaked in water. This cellular structure extends into the radicle and plume, but in much smaller proportion, constituting, according to Grew, about three fifths of the plume, five sevenths of the radicle, and nine tenths of the cotyledon.

Through all the organs that compose the nucleus vessels are distributed, by the medium of which a general communication is established among them. This vascular system is likewise exhibited by Grew in the dissection of a bean (fig. 34, Plate XXXVIII.), in which the vessels are seen to branch off on each side from the radicle, and spread themselves by innumerable ramifications through the cotyledons. From the radicle vessels also pass upwards to the plume. These vessels of the radicle are visible when a transverse section is made through it, as in fig. 33, *a*, Plate XXXVIII., in which they are seen to occupy the middle of that body. When the section is made higher up at the neck of the embryo, as in the same figure, *b*, then the central trunk, surrounded by several smaller fasciculi of vessels, passing to the different parts of the plume, is still more clearly exposed. In many seeds, however, the organized parts are so small that their general structure cannot be traced, except during the progress of their germination. We shall therefore defer the description of them till we come to treat of their evolution, and shall then also go more fully into the structure of the parts just mentioned.

Contained albumen. Within the cells of the cotyledon, in many dicotyledonous seeds, the nutrient matter destined to support the future growth of the embryo is entirely contained. In other instances this matter is only in part received into those organs; and in the *Gramineæ*, and other monocotyledons, it is often placed almost entirely exterior to the cotyledon. This matter is produced from a clear liquor that is secreted in the tunic during the formation of the seed. To this liquor Grew gave the name of *albumen*, from its likeness, not only in appearance, but, as he conceived, in use also, to the white of egg in animals. By Malpighi this matter, considered in connection with the tissue that contains it, is often called the flesh (*caro*) of the seed; and from its being sometimes situated around the embryo, it has been denominated *perisperm* by M. Jussieu. We follow Grew and Gærtner in the use of the term *albumen*, meaning to express thereby, not the primary animal compound to which chemists have of late assigned that term, and which is found but in few vegetables; but that compound substance which, whatever be its situation, quantity, or colour, constitutes the nutrient matter of the seed.

Position of the embryo and albumen. This albumen is a very constant part of the mature seed, but its proportion in some seeds is so extremely small, that the seeds in which it occurs have been termed *exalbuminous;* and in a few instances it seems to be entirely wanting. Its quantity, situation, and figure, in different seeds, are subject to very great variation. In the seeds of the *Gramineæ*, where the embryo acquires only a very small size, the albumen constitutes almost the entire bulk of the seed, and is placed wholly exterior to the embryo. In the *Leguminosæ*, on the other hand, the embryo is more completely developed, and the whole of the albuminous matter is contained within the cotyledons. In beet (*beta*), and many others, the albumen is partly received into the cotyledons, and lies in part exterior to them; and where this occurs the embryo sometimes encircles the albumen, and is sometimes encircled by it. In *Rheum* the embryo is placed in the centre of the albumen, in *Rumex* and some others it is applied on the side of it, in *Atriplex* the long cylindrical embryo surrounds the albumen, in *Böerhaavia* the embryo and its cotyledons cover entirely the granulated substance of the albumen. (M. Jussieu, *An. du Mus. d'Hist. Nat.* tome v. p. 224.) In the onion (*allium cepa*) the embryo makes several curves within the substance of the albumen, and in dodder (*cuscuta*) it is twisted around it in a spiral form; so that the relative positions of the embryo and albumen, as well as their quantity, proportion, and figure, are subject to endless variation.

Albumen of wheat. But however much in these respects the albumen may vary, it is always contained within an organized structure. Sometimes this structure is that of the cotyledon, as already exhibited in the bean (fig. 32, Plate XXXVIII.), the cells of which contain this albuminous matter. Where the albumen is placed exterior to the embryo, as in the seeds of wheat, it is nevertheless contained in a cellular tissue. This is exhibited in fig. 27, Plate XXXVIII., copied from Leeuwenhoeck, in which cells of an hexagonal form are seen to be filled with the albuminous particles that constitute the white matter or flour of that seed. This mealy part of wheat he describes as consisting of minute globules, inclosed in a kind of membrane so exquisitely thin as scarcely to be observed, within which the globules are contained, as it were, in cells. The globules appeared to be of different sizes, not perfect spheres, but having an indentation on one part, which led him to suppose that they were not formed by simple accretion, but by some mode of growth, and that "the membranes which inclose them in cells must be provided with so many veins or vessels, that every particle of meal may have its separate vessel." He even conceived the globules themselves to be inclosed individually in a thin skin or shell; but this opinion he never brought to ocular demonstration. (*Select Works by Hoole*, vol. i. p. 169.) Similar observations on the albuminous part of wheat have since been given by Mirbel; and Kieser and others have delineated the globular particles contained in the cotyledonous cells of the bean and other seeds; so that whether the albumen be situated in the cotyledons, or be placed exterior to them, it is in every case contained in a similar and distinctly organized structure.

Varieties of albumen. In consistence the albumen is said to be either farinaceous, fleshy, or cartilaginous; and it may exist in various intermediate states. The farinaceous kind is readily reduced to powder, and is dissolved by water into a viscous mass. The embryo is generally placed exterior to this species of albumen, as in the *Gramineæ*. The fleshy albumen is more frequent. It is softer than the former, and dissolves by water into a gelatinous mass. It is often entirely contained within the embryo and its cotyledons, and yields the thick oil that is expressed from many seeds. Lastly, the cartilaginous species has a horny consistence, is difficultly soluble in water, and not easily reduced to powder. The embryo is never placed exterior to it, and when it contains oil, this is usually very thin. (Gærtner *de Fructib.* &c. vol. i. cap. 10.)

Uses of albumen. In many seeds the albumen serves as a support and defence to the embryo, as well as for nutriment. If it be removed previous to germination, as was done by Mirbel (*An. du Mus. d'Hist. Nat.* tome xiii. p. 157) in the seed of the onion, and by Dr Yule (*Wern. Trans.* vol. i. p. 591) in different species of *Gramineæ*, the embryo, though planted in a rich soil, and carefully tended, grows but feebly, and for the most part dies.

Vitellus. Besides the albumen above described, Gærtner has revived the use of the term *vitellus*, but employed it to designate a very different part from that to which it was originally applied by Grew. The latter made use of this term to designate the inorganic matter of the mature seed, which in the early stage of its production he called

Of the Seed. albumen (*Anat. of Plants*, book iv. chap. 3); but it is employed by Gærtner to indicate a small membranous body, which in many seeds is placed between the embryo and albumen, and is closely connected with the former, but separates easily from the latter. The figure of this small body is described as being very various in different seeds. It is said not to rise out of the earth during germination; but, like the albumen, seems destined to afford nutriment to the embryo. In the *Gramineæ* it represents a thin scale interposed between the albumen and embryo, to which, from its shield-like form, he gives the name of *scutellum*. (*De Fructib. Plantar.* vol. i. cap. 11.) There can be no doubt that this scutellum of Gærtner is the little "conglobate leaf" first observed in wheat by Malpighi, and which later writers have denominated the cotyledon of that seed. In the next section its form and situation will be clearly displayed.

Section II.

Of the Structure of Monocotyledonous Seeds, as displayed in their Evolution.

Classification of seeds: All seeds have by some botanists been distinguished into such as possessed one or more cotyledons, and such as were entirely destitute of them. In treating of seeds under the two divisions of mono and di-cotyledons, we would not be understood to deny the existence of seeds that possess more than two.

their evolution observed. Some seeds are so extremely minute, that, until lately, their existence was not clearly ascertained; and it is only during their germination that their general form and character can be detected. In many others, the organized parts are so small as to be scarcely capable of demonstration, except by following the progressive changes of form they exhibit in their evolution. We propose, therefore, to select, from each of the two divisions of mono and di-cotyledonous seeds, an example or two of the successive appearances displayed in their evolution, which will, besides, form the best introduction to a knowledge of the structure of the mature plant.

Evolution of wheat. In most of the monocotyledonous seeds the cotyledon does not appear above the soil during germination, but is retained within the coats of the seed, and consequently undergoes but little alteration in size. As an example of the evolution of a monocotyledonous seed, we shall select that of wheat (*triticum hibernum*), because its development has been studied with great care, and, in common with some others of the same natural family, it exhibits some striking peculiarities, which add greatly to its productive powers. The successive appearances exhibited in its evolution have been given with great accuracy by Malpighi, who has carried its anatomy farther, in some points, than most of his successors. In the earlier stages of growth, some very accurate representations of it have also been given by M. Poiteau; and Dr Yule has likewise obliged us with some valuable observations. From these different authorities, confirmed generally by our own observations, we shall endeavour to present a concise view of the structure and evolution of this very important seed.

Description of wheat. If we take a grain of wheat, and examine its convex side, we observe, at its base, a small oblong body (fig. 35, Plate XXXVIII.) lying in a semicircular depression, which is well defined through the tunics that cover it. These tunics are two in number; an outer one, to which the chaffy filaments at the vertex of the seed are attached, and which readily separates when moistened; and an inner one, which everywhere adheres closely to the cellular tissue that contains the albumen. If these two tunics be raised and thrown back, as is done in fig. 36, the little oblong body *h*, and its semilunar appendage *i*, placed behind it, are brought into view; and, together, they constitute the embryo.

Let next a vertical section of another seed be made in the direction of the furrow that runs along its flatter side, and let this section pass through the embryo, as is represented in fig. 37: we then observe the seed to be composed almost entirely of albumen *k*, with which the embryo *l*, consisting of minute convoluted leaves, is in close contact. The part of the embryo that is applied against the albumen is the cotyledon, which on that surface is convex, and on the opposite one concave.

In fig. 38, the entire embryo has been removed from its connection with the albumen, and a front view of it, considerably magnified, is there given, in which the letter *m* denotes the cotyledon, in the concavity of which the plume *n* is lodged, and *o* indicates the protuberances from which the radicles afterwards spring. If now this same embryo be reversed, as is done in fig. 39, then the convex back of the cotyledon only is seen, with the extremity of the principal radicle at the base. It is this side of the cotyledon that was applied against the albumen; and its polished surface, says M. Poiteau, proves that it nowhere adhered by any organic structure. Gærtner also remarks that the connection between these parts is not organic, but merely superficial,—an observation that is true as far as relates to the embryo itself and the albuminous matter, but not as applied to the tunics which envelope them; for, at the base of the seed, the inner membrane, which contains the albumen, appears to be continuous, as Leeuwenhoeck remarked, with that which covers the cotyledon, being reflected from the albumen over the cotyledon, much in the same way as the *pleura* and *peritonæum*, that line the sides of the great cavities in animal bodies, are reflected over the *viscera* they contain. Such are the appearances presented by this seed antecedent to germination: let us next follow it through the several stages of that process.

After a seed of this species has been in contact for 24 or 30 hours with the humidity necessary to its germination, its embryo becomes swollen, and, when removed from the other parts, and moderately magnified, presents the appearance exhibited in fig. 40. In this figure the radicle is rendered more protuberant, and the fine tunic that invests it has undergone an alteration, being changed from a smooth, opaque, and solid texture, to one that is villose, transparent, and cellular. A vertical section of the same embryo, as exhibited in the next figure (41), shows the elongation of the principal radicle *p*, which caused the protuberance below, and the sprouting of the two lateral radicles *p p*, which push forth more slowly on the sides. These three radicles soon force their way through the sac that envelopes them, which then forms sheaths around their origins. In the same figure, the letter *q* denotes the plume, consisting of several convoluted leaves, and resting on the cotyledon. In fig. 42 the appearance of the seed, in a stage a little more advanced, is exhibited. The plume *r* is now seen to have risen above the cotyledon *s*, and the three radicles, surrounded at their origins by their proper sheaths, have greatly increased in length, and innumerable capillary rootlets are emitted from their sides. (*An. du Mus. d'Hist. Nat.* tome xiii. p. 383.)

The daily appearances exhibited in the evolution of this seed, as previously given by Malpighi (*Anat. Plantar.* p. 103), accord well with the above representations of M. Poiteau; and he has noticed some additional particulars of considerable importance. On the first day of germination, he represents the plume of the embryo as beginning to

Of the Seed. open, and the protuberances, which indicate the eruption of the three radicles, as beginning to form. The radicles at this period are completely enveloped in a membranous sac or involucrum; and the body of the embryo is closely connected with a "conglobate farinaceous leaf, by which nutriment is administered." This conglobate leaf is the cotyledon before mentioned, and its connection with the radicle and plume is well shown by Malpighi. In fig. 43, *t*, he exhibits a front view of the radicle and plume, as they appear when separated from the cotyledon; and at the letter *v* of the same figure a back view of the same body is displayed, in which the letter *x* points to the mark or scar that denotes the place of separation. Malpighi believed these parts to be united with each other by a little node, hereafter to be described; but it is by the medium of vessels that this connection between the cotyledon and the other parts of the embryo is maintained; and by this route alone can the nutrient matter or albumen be conveyed through the cotyledon to the radicle and plume. To these vessels M. Bonnet gave the distinctive appellation of *mammary:* the union they form between the different parts of the embryo is so close, that at this part, says Gærtner, the cotyledon, and radicle, and plume, form one undivided body. (Gærtner *de Fructib. Plantar.* vol. i. p. 149.)

e 2 day, On the second day of germination the exterior tunic of the seed, according to Malpighi, gives way; the plume rises upward; the radicles do not as yet pierce their investing sac, but this sac is turgid with juice, and is covered exteriorly by a fine white down: the cotyledon also, at this period, is rendered moist.

e 3 day, During the third day the cotyledon is quite turgid with juice; the plume is much enlarged, and begins to look green; the three radicles have pierced the enveloping sac, and are everywhere thickly covered with hairs; and above the first two lateral radicles, two small protuberances, *y*, *z*, fig. 44, the origins of two more radicles, are now seen to emerge, while the sac that envelopes them is observed sensibly to waste.

e 4 day, When the third day has elapsed, the plume, inclosed in a fine transparent membrane, is still more elevated, and acquires a greenish colour: the protuberances of the two new radicles are more prominent, and the three former radicles have greatly augmented; the cotyledon is much softer, and, as if milky, yielding, when compressed, a white and sweetish liquor.

e 5 day, After the completion of the fourth day, the plume, continuing to ascend, pierces the membranous covering *a'* (fig. 45), and pushes into day a permanent leaf, green and convoluted, around which the membrane forms a sheath. Inferiorly, the first three radicles have greatly extended, and the two others, *b' b'*, are much increased: the outer coat of the seed now begins to lessen, but still contains a sweetish liquor. M. Poiteau gives a section of the entire plantule about this period of its growth, which agrees very exactly with the figure of Malpighi. In this section (fig. 46) the plume *c'* is seen to have pierced the membrane *d'* that formerly inclosed it; the albumen *e'* is diminished; the cotyledon *f'* retains its situation and form; and the five radicles *g' g'* are nearly of a length, and covered with hairs.

e 6 day. About the sixth day the plantule, still invested by its sheath, begins to open and expand; the seminal tunics shrink, and the surface of the outer coat is corrugated. If these tunics are cut open, the cotyledon within is observed in some parts to be firmer than before, and has the appearance of a concave leaf; but in other parts it is more vascular and filled with juice, especially in that part near to the mammary vessels.

After the eleventh day these tunics still adhere to the plantule, but appear much wasted, and the juice they contain is mixed with bubbles of air; while the stem forming many knots, and the radicles emitting innumerable rootlets, continually augment in size. Where the vegetation has been very active, the whole original contents of the seminal tunics are by this time exhausted, and, when compressed, they yield only a watery fluid. 11th day,

After the lapse of a month, when the parts already developed are still farther advanced, new buds break out from the primary seat of growth and rise upward, and new radicles push forth and descend. So readily are these radicles produced, that sometimes, if the primary ones be removed, others in crowds spring forth; at the same time new buds or shoots, protected in their proper sheaths, arise from the same part, and surrounding the primary plantule, are borne upward with it. Of these appearances accurate delineations are given, and they may be observed in every field of growing wheat. 28th day.

The foregoing descriptions of Malpighi are in general very correct, and his figures, though somewhat rude, exhibit faithful delineations of the objects they are destined to represent. In one or two points, however, he has fallen into error, which, in the above statement of his opinions, to avoid confusion, we corrected as we went along. Thus, though he distinctly points out the "conglobate farinaceous leaf" as the organ by which nutriment is administered to the radicle and plume, he assigns to the sac that, in an early state, envelopes the radicles, the function of *placentula*, and even gives to the exterior tunic of the seed the title of seminal leaf. The true cotyledon, however, which never in this seed is produced into a seminal leaf, is the little conglobate body above mentioned; and the common tunics of the seed have no title to the appellation of seminal leaves. To this cotyledon Gærtner, from its shield-like form, gave, as before observed, the name of *scutellum*. He held it to be characteristic of the *Gramineæ*, and analogous to the organ to which, in some other seeds, he gave the name of *vitellus*. (*De Fructib. Plantar.* vol. i. p. 139.) But later writers, as Jussieu, Smith, Brown, and Poiteau, have all restored to it its proper office of cotyledon. Error of Malpighi, of Gærtner,

M. Poiteau has gone even farther, and asserted the existence of a second cotyledon in this seed, and in the oat, which he describes as situated directly opposite to the former. (*An. du Mus. d'Hist. Nat.* tome xiii. p. 388.) In this instance, however, he has mistaken the rudiment of the second bud for a second cotyledon, as Dr Yule ascertained by "tracing the growth of this supposed cotyledon from its first becoming visible to its final development as a plant." (*Werner. Transac.* vol. i. p. 594.) M. Mirbel considers the sac that invests the plantule to be the cotyledon of this seed, and this cotyledon to form the *first ensheathing leaf.* (*An. du Mus. d'Hist. Nat.* tome xiii. p. 148.) But, as already remarked, the cotyledon never in this seed rises out of the tunics; and, as Dr Yule observes, differs totally in situation, structure, and consistence, from the ensheathing leaf of the plantule. of Poiteau, of Mirbel.

A very remarkable peculiarity in these plants is their great reproductive power, as displayed in the indefinite number of new plants which we have seen to be evolved from one primary seed. Malpighi not only observed this peculiarity, but has described the structure from which it originates. He considered the radicle and plume of the embryo to be connected with the cotyledon, not by the mammary vessels, as we have stated, but by a little body which he called the *umbilical node.* In a section of the lower part of the stem of the plantule, made after the third day of germination, he delineates this node as situ- Peculiarity of structure in wheat.

Of the Seed.

ated at the junction of the radicle and plume, as represented by the letter *h'* (fig. 48, Plate XXXVIII.); and describes it as solid exteriorly, and softer and more medullary within. If a section of the same part be made on the fourth day, as in fig. 47, the stem *i'* of the plantule will be seen, says he, to spring from this node, from which also the radicles equally take their origin.

Opinion of Malpighi,

of Leeuwenhoeck,

This peculiar property was also observed by Leeuwenhoeck, though he seems not clearly to have apprehended the nature of the organs from which it proceeded. In the embryo of wheat he describes three points, from which not only three distinct radicles spring, but they are also, he adds, "the beginnings of three several spires or stalks of wheat; so that from every grain of wheat (which is well worthy of observation) there will arise not merely a single stalk, but three distinct ones, which are formed in the seed itself." *Select Works by Hoole*, vol. i. p. 169: and in vol. ii. p. 289, are to be found similar observations on the seeds of oats, barley, and rye.

of Mirbel,

By M. Mirbel, the umbilical node of Malpighi is considered as a fleshy knot (*un nœud charnu*), by the medium of which the plume and radicle are united. The lateral radicles which issue from it he regards as distinct in their nature from the primary one, and as resembling those which spring from knots in the stem; he therefore names them *articular* roots, *les racines articulaires*. (*An. du Mus. d'Hist. Nat.* tome xiii. p. 149.)

of Yule.

According to Dr Yule, however, this fleshy knot is to be considered as a *tuber*, analogous to the tuberous substance interposed between the bulbs and roots of the *Liliaceæ* and other monocotyledonous tribes; and which is destined to produce an indefinite number of young plants, a greater or less number of which are subsequently evolved by the joint agency of the roots and leaves. The "articular roots" of M. Mirbel he regards as in reality young plants, the roots of the *Gramineæ* being invariably fibrous. It is by means of these lateral shoots and their *tubera* that bushes, consisting of from sixty to several hundred stems, are sometimes seen to originate from one seed.

The above important peculiarities in the germination of the seeds of the *Gramineæ* are very perspicuously displayed by Dr Yule in the three figures which we have copied from his Memoir. In fig. 49, Plate XXXVIII., Dr Yule represents the embryo of wheat as it appears when detached from the albumen, a short time after germination has commenced; the ascent of the plume covered with its membrane, and descent of the three primary radicles, which have pierced their containing sac, are clearly exhibited; and the letter *k'* points to the little cotyledon placed at the junction of the two parts just mentioned. In fig. 50 the germination of the same seed is shown in a more advanced stage; the plume *l'* has now risen to a considerable height, and pierced the investing membrane; and at *m'* a second bud or plume (which M. Poiteau mistook for a second cotyledon) is seen to shoot from the tuber like the first. The letter *n'* denotes the seminal tunics. At a still more advanced period, four young plants, *o' o' o' o'*, fig. 51, of the second month, with their sheaths in part withered, are seen to have sprung from the same part; but the two seminal tunics of the seed, exhausted of their contents, still remain attached, as indicated by the letter *p'*. (*Wernerian Trans.* vol. i. p. 589.)

The description given above of the evolution of wheat is applicable, with little variation, to the seeds of all the *cerealia*. The seed of the oat emits from four to six radicles, all of which break through their enveloping sac at the same place, and thus appear to be contained in one sheath. Such too is the case with barley, the plume of which extends beneath the seminal tunics, and pushes out at the vertex of the seed.

This peculiar constitution of the seeds above mentioned is attended with important advantages in their culture, and explains the source of their great productive power. A single grain of barley was observed by Du Hamel to have produced 200 ears, each of which yielded 24 grains; so that one single seed planted in a good soil has produced 4800 grains. Curtis and others, by transplantation of the several plantules of wheat, obtained still higher returns from single seeds. For the same reason, these plants are better enabled than others to resist the injurious effects of accident or disease. If a seed, says Dr Yule, be buried under a stone or lump of indurated clay, the seminal plantules cannot shoot upward; but stems are then sent off in a horizontal direction, until they can effect their escape upward. Sometimes it happens that a small insect (*Musca pumilionis*) deposits its egg in wheat, and the grub is lodged in the very centre of the stem, just above the root, by which the stem is invariably destroyed, and the root so materially injured as to prevent its throwing out fresh shoots on each side, or *stocking* itself, as the farmers term it. Nevertheless, the plants thus attacked are not permanently injured; for, in the instance where these depredations occurred, the crop of wheat was good, and the ears large and fine through the whole field; so that these injured plants, by the production of lateral shoots, yielded an abundant crop. (*Lin. Trans.* vol. ii. p. 76.)

In the germination of other monocotyledonous seeds a similar succession of phenomena present themselves, with the exception of those which relate to the multiplication of so many individuals from a single seed. In all, the radicle first shoots forth, and the plume soon follows; the cotyledon is commonly of small size, and is retained within the tunics. As the embryo grows, the albumen is taken up and conveyed through the cotyledon to the young plantule; and before the albumen is exhausted the embryo is enabled to draw its nutriment from the soil in which it grows.

In many instances it appears that the primary radicle of seeds, after a short time, becomes dry and falls off, and is replaced by a great number of secondary rootlets. M. Poiteau regards this last circumstance as common and peculiar to monocotyledonous seeds. He has remarked it in many hundred palms, not one of which had a descending or tap-root. No plant in the numerous family of the *Liliaceæ* is said to possess such a root. The radicle of the *Cyperaceæ* does not, perhaps, perish so soon; but it does not continue long. This premature and constant destruction of the radicle he considers as the cause of the bulbs and truncations which occur, particularly in the *Liliaceæ*; for the lateral roots not being capable of receiving all the descending sap, it collects at the lower part of the stem, and occasions these different enlargements. (*An. du Mus. d'Hist. Nat.* tome xiii. p. 392.)

The effects which thus succeed to the spontaneous destruction of the radicle occur partly in other plants, in which the first radicle is naturally permanent, if it be artificially removed. Du Hamel found that if the extremity of permanent radicles were cut off, lateral rootlets were produced; that even mechanical obstruction to the descent of the radicle frequently gave rise to divisions in it, and the production of these lateral rootlets. He ascertained also, by experiment, that roots extend invariably, not by an elongation of parts already formed, but by new matter added to their extremities; and hence it is that roots, whether ligneous or herbaceous, do not elongate if even the smallest portion of their extremity be cut off. (*Phys. des Arbres*, tome i. p. 83.) The results of observa-

tions on the growth of carrots in different soils, by Mr Knight, correspond with those of M. du Hamel.

Section III.

Of the Structure of Dicotyledonous Seeds, as displayed in their Evolution.

From the greater number of seeds which have two cotyledons, the phenomena of their evolution may be expected to exhibit at least as great variety as those of the division last described. In different species they differ in this respect as much from one another as they do from monocotyledonous seeds. Some seeds of this class raise their cotyledons above ground during germination; in others these organs are wholly retained within the tunics. Of each of these modes of evolution we propose to give an example, selecting, as before, those seeds which have been most accurately observed; or which, by the forms they exhibit, seem best calculated to illustrate the general laws by which their evolution is accomplished.

In the seeds of this division the embryo is commonly much more completely developed than in those of the class last described, so that the several organs of the plantule become distinctly visible. The radicle and plume are readily distinguished, and the cotyledons are frequently so large as to form nearly the entire mass of the seed. Within the cotyledons the albuminous matter provided for the nutrition of the embryo during its evolution is often entirely contained; and these organs, as before remarked, rise sometimes out of the earth, increase greatly in size, and after a certain period decay. In other instances no increase in size nor elevation above the surface occurs, but, like the greater number of monocotyledons, they remain beneath the soil, and yield gradually their nutrient matter for the support of the embryo. Even in plants of the same natural order, the *Papilionaceæ* for example, some, as *lupinus*, says Dr Smith, raise their cotyledons into the air and light; while others, as *lathyrus*, retain them under ground, concealed within the tunics of the seed. As an example of the latter, we shall give from Malpighi an abridged account of the successive appearances exhibited by the common pea (*pisum*), which, in its evolution, approaches in some respects to that of the seeds last described.

The figure and size of this seed are familiar to every one. After being placed for a day in circumstances favourable to its germination, it is much increased in size; its outer coat is rendered softer, and becomes more white and thin; the umbilical aperture continues closed, but near to it an irregular opening or laceration is visible. If the outer coat be now stripped off, the *nucleus* comes into view. It is seen to consist of two distinct parts or lobes, which are the proper cotyledons of the seed. These cotyledons are closely invested by the inner tunic; externally they have a convex surface, but internally, where they are in contact, their surfaces are nearly plain. Between them, in a small depression formed in their substance, lies the plume: it is composed of a number of yellowish leaves folded on each other, and bent inward, and is united by a little curved stem to a small white conical body, the radicle. These appearances are exhibited in fig. 1, Plate XXXIX., in which one of the cotyledons has been removed, so that the inner surface of the other, together with the plume and radicle, is fully brought into view: the letter *a* denotes the cotyledon, *b* the plume, and *c* the radicle. This radicle at its neck, or point of junction with the stem, sends off on each side a little stalk or pedicle to each cotyledon. In the above figure one of these pedicles has been cut through, and the other, that remains attached to the cotyledon, is concealed behind the plume. It is by these pedicles alone that the two cotyledons are connected with each other. Of the Seed.

When the second day of germination is completed, the cotyledons are rendered more tumid, the tunics give way, and the radicle begins to protrude. Soon after, the cotyledons separate a little, and become somewhat concave internally. After the third day the radicle has pushed out through the tunics; it is white, except at its point, which is more deeply coloured, and it emits on all sides fine capillary rootlets; the cotyledons are now farther separated, and by degrees the stem of the embryo, with its curved plume, is disclosed. 2d day.

About the fifth day the stem *d*, fig. 2, mounts upwards: it is white, and bears on its summit the plume *e*, still curved, and now becoming green: the stem now also begins to exhibit the marks of knots at particular parts: the radicle *f* is farther advanced, and small protuberances, the origins of future rootlets, appear on it: the cotyledons *g* retain their place, are turgid and solid, and still surrounded by the lacerated tunics. 5th day.

At the close of the seventh day the plantule is much more advanced: the knots on the stem *h h*, fig. 3, are quite distinct, and its apex is furnished with broad green leaves, but which are not as yet unfolded. The substance of the cotyledons is still solid, and when compressed yields a bitterish juice: the radicle is much elongated, and has emitted numerous rootlets. 7th day.

After the ninth day the plantule is completely formed: its stem *i*, fig. 4, is now erect, and the leaves of the plume *k* are expanded: the cotyledons *l* are reduced in size: and the radicle *m*, or root as it may now be termed, with its numerous rootlets, is greatly augmented. Every part of the plantule except the cotyledons continues daily to increase: at the end of a month these organs are still found to adhere; but are wrinkled, thin, and exhausted of their nutrient matter, with which the stem and other organs are filled. 9th day.

The progress of evolution in those seeds that raise their cotyledons above the earth is exhibited by Malpighi in that of the gourd (*Cucurbita*). This seed is of an oblong figure, and has a flattened form. It possesses three distinct coats or tunics: the outer one is thick, tough, and coriaceous; the middle one thin, membranous, and of a greenish colour; and the inmost is that transparent colourless pellicle that closely invests, and is inseparably connected with, the cotyledons of the seed. Evolution of the gourd.

After this seed has been made to imbibe moisture, the outer and middle tunics readily separate, and expose the *nucleus*, which is seen to consist of two leaf-like cotyledons, which have no connection with each other, except by the medium of the little conical body, or radicle, at their base. The size and figure of these cotyledons, and the situation of the radicle that connects them, are represented in fig. 5, Plate XXXIX. Their external surface exhibits to the naked eye prominent lines, which indicate a vascular structure, the vessels of which proceed from the radicle at their base. They are commonly five in number, and from their main fascicular trunks ramifications are produced, which, in their distribution, form a finely reticulated appearance over the whole organ. On their inner side the cotyledons are quite plain, and closely applied against each other, but, as already remarked, are nowhere connected, except at the base. This surface is displayed in fig. 6, in which the great vascularity of the organ is rendered more apparent. It is between the two cotyledons that the plume, consisting of minute convoluted leaves, is lodged and cherished. In fig. 7 a part of the nucleus of this seed is represented a little enlarged, and

Of the Seed. the two cotyledons have been removed at different places by transverse sections, to show more clearly the situation of the radicle and plume. The letter *n* denotes the place from which one of the cotyledons has been removed, so as to bring the plume *o* into view; and *p* points to the conical radicle below.

1st day. When this seed has been twenty-four hours in circumstances favourable to its germination, it is rendered tumid, and the umbilical aperture at its base is enlarged by the swelling of the parts within: the cotyledons become turgid, and the plume is augmented in size. After the second day the outer coat is much softened, the middle one appears as if torn and decaying, and all the parts within still further augmented in size. During the third day the colour of the outer tunic becomes darker, the cotyledons are more swollen, their vessels more conspicuous, and the radicle pushes out through the umbilical aperture.

4th day. When the fourth day has elapsed, the plantule is still retained within the tunics; and if these be now removed and examined, the middle one is found to be dry and thin: the cotyledons (*q*, fig. 8) are whitish, soft, and flexible, but the vessels on their surface are much more distinct: the radicle *r* is elongated and covered with down, as likewise is the stem *s*. At the top of the radicle a protuberance is seen, which is white and soft; and farther down appear several smaller tumours, indicating the places of rootlets about to break out.

6th day. About the sixth day the cotyledons *t*, fig. 9, emerge from beneath the tunics, representing the "dissimilar leaves" of Grew, and the "seminal leaves" of Malpighi, but which we shall in future denominate *cotyledonous leaves*. They are thick, soft, and a little separated from each other; their position is pendent; the colour yellowish; they are very vascular, and between them the plume is still concealed. The radicle *u*, at this period, is much elongated, and rootlets everywhere spring from its sides; the stem *v* is also lengthened and curved, and, in common with the radicle, is everywhere covered with a white curling down.

9th day. Towards the ninth day the cotyledonous leaves (*x*, fig. 10) assume an erect position. At their points they are still yellowish, but elsewhere green, and their cellular tissue is filled with a greenish-yellow juice; they begin to separate a little, but still entirely conceal the plume. The stem *y*, at this period, is greatly elongated, and its lower extremity has become green; the protuberance that existed at this part is greatly lessened; and below it the radicle *z* is continued, from which numerous rootlets, covered with capillary productions, break out.

21st day. During the following days the cotyledonous leaves continue to enlarge, the stem to elongate, and the plume to augment in size; but it is not yet unfolded. About the twenty-first day the development of the plantule appears to be completed. A representation of its foliage at this period is given in fig. 13; the cotyledonous leaves, *a'*, have now reached a great size, are of a deep green colour, and very vascular: they rise by a short pedicle from the summit of the stem. On each leaf seven fasciculi of vessels are visible, which, beyond the middle, terminate in a net-work, from which is produced the cellular structure that contributes to form the breadth of the leaf. In the axil, formed by the cotyledonous leaves, the plume *b'* lay concealed; it is now disclosed by the removal of one of those leaves. At first the leaves of the plume are curled and convoluted, but afterwards they expand, and their figure is then seen to differ entirely from that of the cotyledonous leaves; they have notched margins, and their surface is covered with down. In this manner the young plant continues to increase, and acquires at length its full magnitude, in the progress towards which the cotyledonous leaves waste gradually, and finally fall.

Of Seed. Evolution of seed.

The seeds of the radish (*Raphanus*), of the lettuce (*Lactuca*), and of the kidney-bean (*Phaseolus*), are represented by Malpighi as exhibiting, in their evolution, a similar succession of appearances. In all these seeds, and in many others of this division, the radicle first pierces the seminal tunics; next the cotyledons come into view, and assume generally the form of leaves, between which the tender plume is for a time concealed, and at a later period is disclosed. In different seeds, however, the forms of these organs, and the periods of their successive evolution, are subject to the greatest variation, not only as relates to the species of seed, but to the soil, the climate, and season in which it is destined to grow.

Internal structure of seed.

Having thus surveyed the changes in *external* form which the germinating seed exhibits, we shall conclude our description by a display of the peculiarities of its *internal* structure. This we shall find to consist entirely of vessels and cellular tissue, variously proportioned and combined. In a longitudinal section of the radicle of the pea in an early stage, Malpighi represents it, as in fig. 11, to be composed entirely of cellular tissue exteriorly, in the centre of which the vascular system, separating at the top into three divisions to supply the plume and cotyledons, is placed. A similar section of the radicle (fig. 14) on the seventh day exhibits corresponding sections of the rootlets it puts forth; which are seen also to consist of cellular tissue, and of vessels that come off from the central fasciculus of the radicle.

The stem, when about a month old, is composed of a thick bark formed of cellular tissue, within which are several fasciculi of vessels. In some very thin slices of the stem of the pea, viewed through a microscope of considerable power, the arrangement and distribution of the vessels and cellular tissue appeared to us as represented in fig. 15. The centre of the stem was occupied by cellular tissue, round which was a zone of vessels, *c,'* forming four principal fasciculi. Exterior to this zone was a small ring of thickened cellular tissue, and beyond this the proper cellular substance of the bark. Near the circumference of the stem were four larger fasciculi, which may probably be considered as the "proper vessels," while those near the centre may be deemed the sap-vessels.

In the plantule of the gourd a similar structure is observable. In fig. 19 is represented a longitudinal section of its stem and radicle on the ninth day, as given by Malpighi. In this stem the vessels are disposed in a circle that surrounds the pith; but as they descend towards the root, they approach each other, and give off ramifications to form the rootlets. In a transverse section of the stem, on the 21st day, Malpighi describes it as hollow in the centre, around which six fasciculi of vessels are disposed, and the intermediate portion is occupied by cellular tissue. Hedwig and Kieser, however, enumerate not fewer than ten fasciculi of vessels in the stem of this plant, some of which are placed next the pith, and others near to the bark, as in fig. 28.

To these representations of the structure of the pea and gourd by Malpighi, we shall add that of the bean in its early stages, as delineated by Grew, who has traced the distribution of the vessels in the radicle and cotyledons with great minuteness. In fig. 12, Plate XXXIX., is exhibited a vertical section of a young bean, which is made to pass through the cotyledons, the plume, and radicle. From the extremity of the radicle the vessels ascend in fasciculi to the neck of the plantule, where they are seen to diverge towards each cotyledon, and ramify through it, while a

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central vascular portion is continued to the plume. In fig. 20 the vascular and cellular structures of the germinating bean are shown in conjunction, in a highly magnified representation, presented here in a reduced size from Grew. In this figure *d'* denotes the cotyledon, *e'* the enveloping tunics, *f'* the cellular tissue, *g'* the vascular system continued from the fasciculus *h'* in the radicle, and ramified through the substance of the cotyledon; the letter *i'* points to the plume, which also receives vessels from those of the radicle; and *k'* indicates a depression in the cotyledon, in which, antecedent to germination, the plume was partly lodged; a similar depression existed in the other corresponding cotyledon.

CHAP. II.

THE ANATOMY OF THE MEMBERS OF VEGETABLES.

SECTION I.

Of the Structure of the Stem or Trunk.

ART. I.—*Of the Stem in Herbs.*

Stem.

In the foregoing chapter we have traced the successive changes of form which the seed exhibits in its progress to constitute the perfect plant; we have next to display the structure of the plant itself in its more remarkable varieties and forms. The leading features of this structure have already been laid before the reader when discoursing on the *common textures* of plants: it remains now to exhibit individual examples of it, as they occur in the several members of the trunk, the branch, and the root.

Names of stem.

Botanists employ different terms to distinguish the different kinds of stems or stalks that support the leaves and the organs of fructification. These are the stem (*caulis*), which is considered peculiar to herbaceous plants; the trunk (*truncus*), which is proper to herbs and trees; the straw (*culmus*), which is the appropriate stem of the grasses; and the stalk (*scapus*), which differs from the other varieties in bearing flowers only, and not leaves. For the peculiarities in external form and character which distinguish these several kinds of stems, as they occur in different species of plants, we must refer to the writers on botany; and shall proceed to exhibit a general outline of their internal structure.

Stem of sugar-cane.

Perhaps there is no plant in which the simplicity of vegetable organization is more clearly displayed than in the sugar-cane, which belongs to the family of *Gramineæ*. In its stem or culm the cells and vessels are comparatively large, retain much of their more perfect forms, and are quite distinct from each other. When treating of the cellular tissue we referred to the cells of this plant exhibited in the very thin transverse slice, fig. 16, Plate XXXIX., as illustrative of their hexagonal figure, and of their being bounded on every side apparently by a single membrane. In some parts, when the observer is viewing these cells through the microscope, some of them appear quite transparent, from the upper and lower bounding membranes being entirely removed, and the light, in consequence, being freely transmitted; but in others one or both of these membranes remain, and though they are exquisitely thin, yet, when viewed by a strongly reflected light, a degree of refraction seems to be produced, which communicates to the surface of the membrane an irregular appearance, such as it has been attempted to express in the darker cells of the same figure. The deception that arises from viewing two layers of these cells in conjunction, which imparts the appearance of double sides, as in fig. 21, was before noticed; and the longitudinal appearance of the same organs, as seen both in a single and double series of columns (fig. 22 and 23) was at the same time described.

It is through this cellular structure that the vessels which constitute the other component part of the culm of this plant are distributed. They occur in fasciculi, which, towards the centre, are placed at considerable distances from each other, and preserve a symmetrical arrangement; but nearer to the circumference they are more numerous, and their distribution is much less regular. In fig. 25, Plate XXXIX., a very thin transverse slice of this plant is exhibited, in which this regular disposition of the vessels at and near the centre *s' s'*, and their crowded state near the circumference *t'*, are well shown; the cells, too, at the centre are larger, and have a more perfect form than those near the circumference of the figure. In fig. 27 a very thin longitudinal slice of this same plant is delineated; it is considerably magnified; the letter *u'* denotes the cellular tissue, and *v' v'* two fasciculi of vessels which ascend through it.

Stem of the palm;

In the palm, which, though belonging to the division of trees, we shall notice in this place, a similar disposition of the elementary organs is observed; but both the vessels and cells are smaller than in the sugar-cane, and the fasciculi of vessels are also much more numerous. This structure is exhibited in the transverse section of the trunk of the palm, fig. 26, in which the dark spots indicate the vascular fasciculi, and the whiter portion the cellular tissue. As before observed in the sugar-cane, the vessels are seen to be less numerous at the centre than at the circumference, where they are much crowded together, and very irregularly distributed, in consequence of the peculiar mode in which the growth of these trees is accomplished.

In fig. 24 of the same plate we have also copied from M. Desfontaines a portion of the longitudinal section of the trunk of another species of palm (*dracæna draco*), which displays more clearly the irregular direction which the vessels take in the lax cellular tissue through which they are distributed. It was before remarked that these plants do not naturally produce branches, but that their vascular system is expended wholly in the production of leaves at their summit, and their trunk is perfectly cylindrical. If, however, the top of the plant has been cut off, or broken by accident, a division into branches is said to take place. (*Mém. de l'Instit. Nat.* tome i. p. 486.)

As in these plants the ligneous and cortical textures are uniformly blended together through the entire stem, it must be presumed that the *sap*-vessels and *proper* vessels are everywhere associated. This fact is accordingly pointed out by Malpighi as occurring in several species of the *Gramineæ*, who, as we before remarked, delineates a *proper* vessel as existing in each fasciculus of sap-vessels.

Stem of the gourd.

The next variety of structure we shall notice is that of certain herbaceous plants, in which the proportion of cellular tissue in the stem much exceeds that of vessels; and, though belonging to the division of dicotyledons, they in several points resemble in structure those just described. In a section of the pea already given (fig. 15, Plate XXXIX.) the greater portion of the stem was seen to be made up of cellular tissue, through which several fasciculi of vessels were dispersed. The stem of the gourd has been examined with great minuteness by M. Kieser, who has represented in several sections, both transverse and longitudinal, its appearance in different parts at different periods of its growth. The total number of fasciculi of vessels that exist in the mature stem of this plant he

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makes, with Hedwig, to be ten; but the number of vessels in each fasciculus he shows to vary at different periods, and in different parts of the same plant, according to their relative age. In fig. 28, Plate XXXIX., is a piece of the stem of the gourd, cut horizontally near the root, of its natural size and appearance, as represented by Kieser. The portion *l'* of this figure is represented in fig. 29, magnified 130 times: it comprehends only *one* of the 10 fasciculi of vessels that exist in the stem. In this magnified view the letters *m' m'* indicate the elongated cells of the bark; *n' n'* the larger cells, which form the parenchyma of the stem; *o' o'* the cells which surround the fasciculus of spiral vessels; *p' p'* the fasciculus of spirals, containing 29 vessels, in part simple and in part punctuated spirals; *r' r'* the great cells situated towards the centre of the stem: at *q'* are four spiral vessels of different sizes, filled more or less with small punctuated vesicles, which spring from the walls of the vessel, and in two instances nearly close up their cavities.

The horizontal sections of the stem of the gourd exhibited above are taken from the same plant as the vertical sections of the vessels in figures 13, 14, 15, &c., Plate XXXVIII. The number of fasciculi that exist in the stem of this plant is 10; but the number of vessels in each fasciculus continually increases as the plant approaches maturity, and varies even in different parts with the different stages of its growth. Thus, of six sections made of the stem, that taken near the summit, and therefore of latest growth, exhibits only six or seven vessels in each of the 10 fasciculi, corresponding in this respect with the number found near the bottom in the earliest stage of growth. In the next section, made through the internodial space below, the vessels in each fasciculus have increased both in number and size; in the third section, the vessels have still further increased in size, and in number amount to 19 in each bundle; still lower down, in the fourth internode of the same stem, both the number and size of the vessels go on augmenting. In the fifth section, taken at the largest part of the stem, a still further increase in size is found, and the number in each fasciculus amounts to 23 vessels. Again, the section made in the stem of the same plant very near the root, and taken at a more advanced age in autumn, exhibits vessels approaching in character to those of the ligneous part of trees, and now amounting to 29 in each fasciculus. It is this last section which we have copied above in fig. 28 and 29, where the vessels may be seen smallest next the pith, and gradually increasing in size as they recede from the centre towards the circumference. Lastly, in a section of the branch of the root of the same plant, in place of 10 fasciculi of vessels met with in the stem and in the principal root, there were only four, but each fasciculus contained 37 vessels: the cells of this part were smaller than in the stem, and the whole construction was comparatively more vascular and compact.

The general characters of these vessels, from the earliest period of their development to the mature state of the plant, and the successive changes in size, in form, and appearance which they undergo, have been already exhibited in the series of figures 13, 14, 15, 16, 18, 19, of Plate XXXVIII., representing vertical sections, corresponding to the horizontal ones just described. As the plant increases in age the vessels augment in number, and in character they approach to those of arborescent plants: their sides are thickened, their transparency is almost lost, and the cavities of some are filled by vesicles. The balance, also, in the different orders of vessels at mature age is nearly the reverse of that which obtains in youth. In the young stem, says Kieser, the *simple* spirals are to the punctuated variety as 17 to 6, while in the adult plant there are only 6 simple spirals to 23 of the punctuated variety in the stem; and in the root the simple spirals, which at first were equally visible, have altogether disappeared. A metamorphosis of the simple into the more complex varieties of vessel must, therefore, during the progress of growth, be deemed to take place.

In the stem of the gourd, as thus described, we observe an arrangement of parts in many respects agreeing with that of the sugar-cane. In both, the cells in certain parts are large, and their figure is well preserved; and the vessels are distributed in distinct fasciculi through the cellular tissue. In the gourd, however, the fasciculi are fewer in number, and do not suffer that displacement during the progress of vegetation which those of the cane experience. In neither plant are the vessels so numerous, or so situate, as to compress the cellular tissue into transverse partitions; nor is there in the transverse section of either any appearance of concentric layers. In neither stem is there any proper pith, the central part of the sugar-cane being occupied by cells and vessels, and that of the gourd being alike destitute of both.

In the sections of various herbaceous stems represented by Grew and Malpighi, the number of vessels and their disposition exhibit the greatest variety, and approach more or less to the arrangement of parts that is found in shrubs and trees. Thus, in holly-hock (*Alcea*) Grew describes the vessels of the bark as yielding a thin mucilage, and within them are the sap-vessels, postured in short rays, which comprise twelve or sixteen vessels. In *Scorzonera*, the "proper vessels" in the bark yield a milky fluid, and are postured in a radiated manner with the sap and spiral vessels that extend to the pith, all of which form parts of the same radiated lines. (*Anat. of Plants*, p. 103.) In endive, Malpighi describes the structure of the stem as approaching in character to that of trees. Near the circumference the vessels, says he, are disposed in lines directed towards the centre, and are separated by small ranges of cellular tissue, which is compressed into a solid and dense form; and more interiorly the vessels are larger, and extend a considerable way in rays through the stem. (*Anat. Plantar.* p. 25.) Where the vessels have this radiated position, the cellular tissue between them assumes the form of membranous partitions; but the greater portion of the stem of this plant is occupied by cellular tissue, not thus compressed into a membranous form. We thus clearly observe that, even in herbaceous stems, membranous partitions, extending more or less completely through the stem, are formed, whenever the vessels are disposed in radii, and are sufficiently numerous to compress, on either side, the cellular tissue that envelopes them.

Art. II.—*Of the Trunk in Shrubs and Trees.*

In shrubs and trees the several textures that compose the trunk are commonly distinct from each other; and some parts that are but imperfectly distinguished in herbs become in them well defined. In the trunks of these plants, however, though a general uniformity of structure is observed, yet particular modifications of it exist in every species, and these are still further varied by the peculiar nature of the individual plant, and the mode and circumstances of its vegetation. Before descending to particular examples, it may be useful to exhibit a concise view of the parts that compose the trunk, and the terms employed to denote them.

Externally in every tree we have the skin or cuticle, the structure of which has been already described in a former section. In very young plants, and in young

branches, it is succulent, and its surface is entire; but in older trunks and branches it is frequently dried and broken, and in some instances is thrown off; so that the exterior covering of the plant appears to be formed by the cellular tissue of the cortical texture.

Beneath the skin is the bark, constructed, as we have seen, of cellular tissue, and of vessels collected into fasciculi, which at first are straight, and run parallel to each other; but, by the subsequent augmentation of the parts within, are separated at certain places, and touch only at a few points, so as to form a reticulated appearance. In the annual shoot only a single ring of vessels is observed, and these, with the tissue in which they are placed, form the *cortical layer*, as it has been called, of that period. Within this layer a new production of vessels and of cellular tissue takes place; and this being annually repeated, constitutes the series of layers of which the bark is ultimately composed. The new layer that is thus annually formed, and which appears to exercise an active vegetative function, was more particularly distinguished by the appellation of *liber* by the ancients, from its being the substance on which, before the invention of paper, they were accustomed to write. Very frequently, instead of a ring, the vessels of the bark are collected into distinct parcels or clusters, which, in the progress of vegetation, assume very different shapes.

Next to the bark is placed the wood, constructed, like the bark, of vessels and cellular tissue. Like it, too, it consists, in the young plant and in the annual shoot of the older one, of a single ring of vessels, which immediately surrounds the pith. In the following year a new ring of vessels is formed around the first, and in every succeeding year this process is repeated; so that the wood consists at length of a series of rings inclosing each other, the number of which denotes the age of the tree. The outer ring of newly formed vessels is more succulent than those of older growth, and is generally of a whiter colour; whence it has received the names of sap-wood or *alburnum*. By Du Hamel and most French writers it was named *aubier*, and by Hill it was called the *blea*. In every annual shoot the newly formed liber and alburnum are in contact, but in every succeeding year they are separated more and more from each other by the interposition of new matter between them; so that at length the first layer of bark and the first ring of wood occupy respectively positions the most distant; those, namely, of the centre and circumference of the tree.

The vessels that are thus annually formed, and constitute the alburnum, are disposed in *radii* which extend more or less completely from the circumference to the centre. In some trees the vessels are much more numerous than in others; and, in the progress of vegetation, they frequently suffer great alterations in size and external figure, as was before observed when treating of the vascular system. In the alburnum the size of the vessels is very uniform, and so it continues ever after in some trees; but in others it is very various, some being enlarged more than others by a greater influx of sap. With this increase of size the vessels seem to acquire the spiral character. They are also frequently closed up in the more aged parts of trees, by the production of vesicles within their cavities; and, in common with the smaller vessels and the cells, they are in some trees ultimately filled with gummy or resinous matter. In other instances, where the "proper juices" of the plant differ but little in quality from the common sap, the vessels, when no longer employed in active vegetation, become dry, and appear in some plants like empty capillary tubes; and in others, from the minuteness of their size, no aperture is visible. In this state they have been regarded as solid filaments, and denominated the *ligneous fibres* of the plant.

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Ligneous fibres.

From the disposition of the vessels in *radii* more or less regular, the cellular tissue by which they are surrounded will be more or less compressed in the same direction, and form those transverse partitions between the several rays of vessels which we have already so frequently noticed. In addition to these fine partitions, described both by Grew and Malpighi, which are thus interposed between every ray or line of vessels, larger portions of cellular tissue are observed at certain distances, which extend in the same direction through the wood, and in some instances are continued through the bark also. By the authors just mentioned these partitions were described as stretching from the bark towards the pith, and were named *insertments* by Grew, and *transverse utricular ranges* by Malpighi. Others have held them to proceed rather from the pith to the bark, and have called them *medullary rays*. We shall venture to name them in future *transverse septa*, which appellation denotes simply their direction, and the fact of their forming partitions between the vessels, without having any reference to their origin. For similar reasons, the finer partitions of cellular tissue, previously described, may be denominated the *lesser transverse septa*.

Transverse septa.

Longitudinal septa.

Beside these transverse septa, there are sometimes portions of cellular tissue intercepting the vessels in a longitudinal direction. This was remarked both by Grew and Malpighi in the oak and several other trees: they appear sometimes to be very short, and sometimes to form nearly a continuous ring around the trunk. It is probable they are formed simply by the pressure of the vessels acting in a direction opposite to that by which the transverse septa are produced: they may, for distinction's sake, be named the *longitudinal septa*. In many trees they are not to be observed, or, if they exist, are so thin as to form only a sort of *fascia* on the adjacent vessels. To the cellular tissue promiscuously intermingled with the vessels some writers give the name of *parenchyma* of the wood: others term the elongated cells of this part ligneous fibres.

Parenchyma.

The pith.

The only other part of the trunk that remains to be mentioned is the pith. It is situated at the centre, and is surrounded commonly by a ring of vessels, but sometimes in part by thickened cellular tissue. Its proportion in shrubs is usually much larger than in trees; and in the young shoots of trees it occupies more space than in the older branches. At first in the young plant it is succulent, but afterwards becomes dry; and in aged trees it frequently is entirely obliterated, or at least rendered solid.

Trunk of the vine.

In a description of the growth of the trunk in a young plant of chesnut, Malpighi has given clear views of the gradual development of these several parts, and exhibited the appearances successively displayed in the first years of growth. (*Anat. Plantar.* p. 35.) In the vine some of these parts are very distinct. Fig. 1, Plate XL., represents a transverse section of the annual shoot of this plant. The pith *a*, in the centre, is large, and composed of cells of different sizes. From the pith to the skin in the vine, and, according to Grew, in the elm and some other trees, extend the transverse septa *b*. In some places the cellular structure of these septa in the recent plant is still visible, as at *c*; but generally they have the appearance of thickened membranes. Between every two septa two or sometimes three lines or rays of sap-vessels are interposed, which from their size are readily visible, and their place and disposition are indicated by the dotted marks *d*: the circular ring that bounds these sap-

Of the Trunk.

vessels seems to be formed of condensed cellular tissue, and exterior to it the "proper vessels" are placed in the cellular tissue of the bark.

Trunk of the apple;

In the next figure (fig. 2) is exhibited the transverse section of an apple-branch of one year's growth, which, like the former, is considerably magnified. The angulated figure and relative size of the pith at this period are shown. From the pith to the bark proceed numerous very fine septa, possessing somewhat of a curved direction; and between them innumerable black points, indicating the sap-vessels, are seen. These vessels are disposed in radii, and are bounded exteriorly by the thickened tissue of the bark: the bark is proportionally large, and in the midst of its cellular tissue clusters of "proper vessels," *e*, are observed.

In a similar section of the apple-branch of two years' growth, fig. 3, more highly magnified, the pith *f* is seen to have assumed a rounder form: from the pith towards the bark the transverse septa extend, between which the vascular radii are situate. The letter *g* denotes the place of junction of the two years' growth; *h* the newly formed alburnous vessels, situate between the bark and the wood; and *i* two ranges of "proper vessels," placed in the cellular tissue of the bark. Grew gives a highly magnified view of a section of this same plant about the third year of its growth, in the 25th table of his work, the appearances of which correspond with those just related, except that the transverse septa, as in all his figures, are made to represent straight lines, which, in the earlier periods of vegetable growth, does not appear to be quite correct.

of the oak;

Proceeding next to the plant of more mature age, we shall copy from Grew part of a section of the oak, which in fig. 4 is exhibited on a reduced scale. The letter *k* denotes the bark, *l* the alburnum, *m* the wood, and *n* the pith. In this section the larger transverse septa *o*, and the smaller ones *p*, are very distinct, between which the sap-vessels of different sizes, indicated by the dark points, are situate; the letter *q* points to the "proper vessels" of the bark, some of which are collected into round parcels, and others form a ring.

Beside the transverse septa that intersect the diameter of the tree, we observe, in this figure, other lines, *r*, placed at right angles to them, and which appear to be interposed between each annual ring of wood. Grew considered it probable that these lines were produced in the oak, and also in the fig-tree and walnut, by a peculiar sort of sap-vessels that existed once in the bark, as did the turpentine vessels distributed through the wood of the pine. (*Anat. of Plants*, p. 115.) Hill also calls them sap-vessels seated on the outer edge of each annual circle, which in the young plant contain sometimes a limpid liquor, and at other times appear empty. He notices also the existence of "proper vessels," containing a thick juice in the alburnum of this tree. (*On the Construction of Timber*, p. 9.)

of very old oak.

An examination of this wood at an age still more advanced may contribute to throw some further light on its structure. In fig. 5 is given the representation of a transverse section of the central portion of a piece of the wood of very old oak, of its natural size and appearance. The pith *s*, at the centre, was completely obstructed, and its cellular character obliterated; the letters *t t t* denote the larger transverse septa, rendered completely solid everywhere, and in some places partially obliterated; and *u* the white lines that extend in the opposite direction, and mark the boundaries of each year's growth. In the substance of these concentric lines numerous traces of minute apertures were visible; and from one line to another, small irregularly curved lines, as represented in the drawing, were everywhere observed to extend. No vacuity was anywhere perceived to exist, but the whole formed one compact and solid mass.

A small and very thin slice of this wood, comprising a part of one of the larger transverse septa, and small portions of two of the concentric lines above mentioned, was submitted to a pretty highly magnifying power; and a delineation of its appearance is given in fig. 6. In this figure the letters *v v* denote the two concentric lines; *w* one of the smaller irregular lines that frequently extend from *v* to *v*, but are often intercepted, and form irregular spots or patches, as traced in several parts of the drawing; *x* the smaller transverse septa, situated at unequal distances from each other; and *y* the larger septum, the cellular character of which is entirely obliterated. Several small irregular lines, running in the same direction with the larger concentric ones, are also observed: these, at their junctions with the lesser transverse septa, produce a number of little squares, the areæ of which are filled up with a dotted or punctuated membrane.

This microscopical representation seems to confirm the opinion of Grew, that the concentric lines *v v* are chiefly composed of vessels; for their apertures, now rendered visible, are of different sizes, and the canal of many of the larger ones is filled up with a vesicular substance, often observed in the vessels of aged plants. The substance that surrounds these vessels appears to be condensed cellular tissue, rendered perfectly solid by the resinous matter with which it is filled. The irregular thickened lines *w* that run transversely to the former are similarly composed of vessels and condensed cellular tissue; and the smaller patches, we have noticed, are made up of the same. Both the large and small transverse septa consist of condensed cellular tissue alone; and such, too, appears to be the matter of which the fine lines or longitudinal septa that intersect them are composed. Some observations of Du Hamel on the formation of the ligneous layers may aid our inquiries into the nature of these latter septa, and the minute structure of the wood.

In a transverse section of the trunk of the oak, the elm, or the fir, says this very intelligent writer, the ligneous layers are distinctly visible, and it is commonly believed that each of these layers is the product of one year's growth. If, however, we cut obliquely a piece of oak, each layer is then seen, with the aid of a common lens, to be composed of a number of thinner layers, which mutually cover each other. By macerating pieces of wood in water, he was able to separate the annual layers into a great number of leaflets, thinner than the finest paper; and these primary layers, as they may be called, he afterwards ascertained by experiment to be formed successively during the whole period of active vegetation; so that the layer which is the product of one year's growth is itself formed of a number of layers exceedingly thin. (*Phys. des Arb.* tome i. p. 31, and tome ii. p. 19.)

Now it is probable that between each of these primary layers cellular tissue is interposed; and this tissue, by its compression, gives origin to the minute lines which in this tree have been noticed. In several trees, however, no similar lines are visible, because in all probability they do not, like the oak, afford secretions by which the tissue is thickened and rendered apparent. Even in a very thin slice of oak, when viewed in the microscope by a strongly reflected light, these lines almost entirely vanish, while those of the two orders of proper transverse septa remain.

M. Kieser examined the same wood in the transverse slice of a tree 100 years of age: and his representation of its structure is copied in fig. 23, Plate XL. In this figure, in

which the appearances are magnified 130 times, *a′ a′* indicate the cellular tissue, or, as he calls it, the parenchyma of the wood. At the top and bottom, the cells are obstructed and appear like obscure points (as is the case also in fig. 6 of the same plate); but in the middle of the figure the cavities of the cells are said to be still visible: the letters *b′ b′* denote the apertures of enlarged spiral vessels, all of which were filled with vesicles, but a few only are so represented, as in *c′*; *d′* indicates the smaller vessels dispersed through the cellular tissue; *e′* a portion of one of the larger septa, and *f′* the smaller ones, which are often displaced by the augmentation in the size of the vessels.

In this highly magnified representation by Kieser, there is no appearance of the concentric lines or septa which intersect the transverse ones, as noticed by Grew and Malpighi, and exhibited in fig. 5 and 6; but the two orders of transverse septa remain. We before remarked, that in a slice of wood so very thin as, when viewed by a strong light, to become translucent, these lines in a great measure vanished; and in the figure of M. Kieser this evanescence is made to extend even to the thickened portion that intercepts the annual layers. It is therefore probable that all these appearances of concentric or longitudinal septa are produced simply by the thickening and compression of the cellular tissue in the oak, and such other trees as have viscid juices, and whose vessels are subject to irregular enlargement; for in whatever position these thickenings occur, numerous vessels are always to be observed. Hence in very thin slices they entirely vanish, while the proper transverse septa, being formed by the condensation of continuous portions of membrane, remain visible. In these figures it may also be remarked, that the surface occupied by cellular tissue seems equal nearly to that occupied by vessels; but it is probable that the apertures of many minute vessels dispersed through the tissue have not been distinguished from the cells. In a highly magnified representation, however, of the wood of this tree by Grew (*Anat. of Plants*, tab. 3, fig. 7), the proportion of the vascular to what is deemed the cellular part is still less.

The vessels of the bark in the oak, as delineated by Grew, fig. 4, Plate XL., are represented as disposed partly in parcels and partly in a ring; and in all the representations he has given of different trees, the greatest diversity in regard to the position of these vessels is found to exist. From the difference in the qualities of their juices, in the texture of the parts, and in the modes and circumstances of their growth, this variation may be expected to occur. In the oak, the pine, and many others, it seems certain also that a part of the cortical texture, or at least vessels containing the "proper juices" of the plant, are constantly mixed with those of the ligneous texture, and with them contribute to form each annual layer of wood. For examples of the diversity of structure exhibited in the trunk of a great many different trees, we may refer to the plates of Grew.

Section II.

Of the Structure of the Branch and its Appendages.

Art. I.—*Of the Branch.*

From the trunk springs the branch, which in structure resembles very exactly that of the trunk itself; and hence the description of the one serves entirely for that of the other.

Branches, in common with leaves, originate from buds, of which we have subsequently to treat, introductory to a description of leaves. At present we shall describe only the mode of connection between the trunk and the branch.

Of the Branch.

The branch, says Grew, springs not from the surface, but so deep as to take with it not only the bark and the wood, but the pith also, making its way at the parts where the vessels are separated by the transverse septa, and carrying with it the skin, which is extended with it. (*Anat. of Plants*, p. 28.) The separation of the vessels of the trunk to form the branch is not like the separation of a few filaments from a skein of thread; but they spring, says Du Hamel, from a centre, and bear with them a part of each portion of the tree. Hence, if a tree that is divided into two branches be cut a foot above the bifurcation, the surface of the sections resembles that of two trunks cut horizontally: if the section be made lower down, at the place where the branches spring, the same appearances of two series of concentric circles are seen at the axis of the trunk, but they are surrounded by other layers common to those which belong to each of the branches; and still lower on the trunk the concentric circles belonging to each branch diminish, and are finally lost in those which form the trunk from which they sprang. (*Phys. des Arbres*, tome i. p. 93.) These primary branches divide into others, and these again into still smaller branches, which form angles with each other, more or less great, according to the species of tree, and other causes.

its connection with the trunk.

The position of the branches on different trees is very various, but in the same species it is generally uniform. From the measurements of Du Hamel, it appears that in many trees the solid matter of the branches that go out from the trunk exceeds that of the trunk itself in the proportion nearly of five to four. (*Phys. des Arbres*, tome i. p. 96.)

Origin of branches, by Hill.

Some have supposed that the branches proceeded always from, and were nourished by, the pith; but this opinion has been combated by Du Hamel and Hill. The latter gives a longitudinal section of the trunk of a species of American dog-wood (copied in fig. 7, Plate XL.), representing the origin of two buds *g′ g′*, which are seen in the state of pushing out on either side through the vessels of the wood. In this trunk the pith is of a brown colour, the inmost ring of vessels green, and the outer ones white. Through the white rings the inner green vessels are seen to shoot, and the brown pith is left entire behind; though the new branch at length obtains a pith for itself, which, however, has no connection with that of the trunk. In a similar section of an older trunk (fig. 8), the branches are seen to spring also from the inmost circle of wood; the pith *h′* is not at all disturbed, but each branch is furnished with its own pith *i′ i′*. In a section of the vine (fig. 9), a similar origin of the branches, from the inmost circle of wood, is observed; and not only is the pith *k′* of the branch distinct from that of the trunk, but the pith of the trunk itself is intercepted by the shooting of a branch *l′* across it. (*On the Construction of Timber*, p. 35.) This latter fact of the interception of the pith by the shooting of a branch across it was previously noticed by Grew in the vine and some other plants. (*Anat. of Plants*, tab. 19.)

When a bud thus protrudes to form a branch, the perpendicular vessels of the trunk are compelled to separate; and they afterwards meet above, and pursue their former direction. This is shown in fig. 11, Plate XL., copied from Du Hamel, in which the bud *m′*, in the act of sprouting, is seen to push to either side the vessels of the trunk, which again meet above it.

The vessels both of the wood and bark, according to the same author, have their direction determined chiefly

Of the Branch.

by the course of the sap. If the sap preserve a perpendicular direction, as in trees that have no branches, the vessels are perpendicular also; but if it move to one side, these vessels then change their direction. This is strikingly evinced in a tree that has been cut over above a branch; for then all the sap being obliged to pass to the young branch, the vessels all at once take the same direction; so that if a tree has been cut over in winter, and at the end of the succeeding spring its branch below be examined, the new vessels of the branch will be seen to cross those of the trunk, as exhibited in fig. 12, *n'*, Plate XL. (*Phys. des Arbres*, tome ii. p. 53.)

Corona.

In figures 7, 8, and 9, copied from Hill, the young branch, in every instance, is seen to originate from the inmost ring of vessels that surrounds the pith; and he was of opinion that all buds and branches sprang from this part alone. To this vascular circle he gave the name of *corona*, and held it to be the most important part of the vegetable body,—that it was like no other part of the plant, but contained within itself the essence of them all. (*On the Construction of Timber*, p. 21.)

It is however notorious, that trees in which not only this first circle, but almost every other circle of vessels, has perished, produce leaves and shoots from the trunk where the bark is entire, as this author himself admits, p. 44 of his work. There does not appear, either in the anatomical character, or in the functions of this circle, any thing that distinguishes it from the others, except priority of formation, and its being in consequence the seat from which the *first* buds and branches spring.

Origin of branches, by Du Hamel.

A much more correct idea of the origin of buds and branches was entertained by Du Hamel, who illustrates it by the diagram fig. 10, Plate XL. Let us suppose this figure to represent a tree of four years' growth, as indicated by the four ligneous cones which at its base envelope each other. In the first year a bud *o'* springs from the inmost ring, which by the fourth year is seen to consist of four ligneous layers. In the second year a second bud *p'* springs from the ring of that year, and consists only of three layers; the next year a bud *q'* is developed on the first bud *o'*, and possesses only two layers; and the bud *r'*, developed the fourth year on the outmost ring of wood, is seen to consist only of one layer. (*Phys. des Arbres*, tome ii. p. 53.) In this way every ligneous layer may be considered equally capable of giving origin to buds and branches.

Art. II.—*Of Thorns.*

Thorns, abortive branches.

Connected both in origin and in structure with branches are those appendages, frequently observed upon them, called thorns. They are very conspicuous on the hawthorn, and are constituted, says Grew, of the same parts as the bud itself, and in a like proportion. They spring from the outer portion of the ligneous texture, and may be considered as abortive buds. (*Anat. of Plants*, p. 33.) Malpighi describes them as being frequently produced in the axils of leaves, and assuming for a time the form of a branch, but at length degenerating into a thorn. He considers them to arise from defective nutrition, and adds, that they disappear frequently under higher culture. (*Anat. Plantar.* p. 138.)

According to Willdenow, most species of our fruit-trees naturally possess thorns, which disappear entirely and become branches under higher culture. Even in the black-thorn the prickles diminish in number under improved culture, but do not entirely disappear.

Other origins of thorns.

Sometimes, however, instead of being produced from abortive buds, thorns owe their origin to the degeneration of other organs; the petioles of some pinnate leaves which are persistent become thorns, and the same thing is observed of the peduncles of some flowers. Certain stipulæ also, as those of Mimosa, are said sometimes to change into thorns (*Principles of Botany*, p. 270); and in the date, according to M. de Candolle, a lobe of the leaf has been converted into a thorn. (*Théorie Elément. de la Botanique*, p. 344.) In other instances, as in the holly, the leaf produces thorns round its entire margin, which are formed by the vessels that bound it. (See fig. 11, Plate XLI.)

When the bark is removed from a branch that possesses thorns, the thorns still remain, by which they are distinguished from prickles that originate from the bark. In fig. 20, Plate XLI., is a representation of a branch deprived of its bark, in which thorns of different forms are seen to spring from the ligneous texture; and in fig. 21 of the same plate is a longitudinal section of another branch covered with its bark, in which the ligneous and cortical textures of the thorn are displayed. For the descriptions of the varieties of thorns, and their external appearance, we must refer to the writers on botany.

Art. III.—*Of Claspers and Tendrils.*

From the similarity in structure which these bodies exhibit to the branches from which they spring, we have placed them as appendages to those members. As is well known, they are met with only in certain plants, and their obvious use is to attach the different parts of the plant to one another, for mutual support, or to the objects in their neighbourhood. In a general manner they are denominated *fulcra:* the most remarkable species are those which, like the claws of ivy, called *claviculi* by Malpighi, are not rolled into a spiral form; and those of the vine, named tendrils (*cirri*), which possess a spiral conformation.

According to Malpighi, the claws or claspers of ivy possess a roundish form, and are covered with hairs, which yield a viscous humour, by which they are agglutinated to stones or to walls and trees. Their forms are exhibited in fig. 22, *e' f'*, Plate XLI., copied from Malpighi; and in the lower part, *g'*, of the same figure, their origin and structure are displayed. They are seen to spring from the ligneous texture of the stem, and to possess a similar structure.

The tendril is described by the same author as springing from knots between the origins of leaves. It possesses a round stem, which is sometimes covered with hairs; and this stem frequently divides into several branches. At first it is very tender, but gradually acquires solidity, and assumes the spiral character; its colour is green, and it is composed, like the trunk, of all common textures. (*Anat. Plantar.* p. 139.) By Willdenow it is regarded as an abortive leaf, being simply a prolongation of the petiole, without the leafy expansion. (*Principles of Botany*, p. 272.) Its form, as it occurs in the vine, is exhibited in fig. 23, Plate XLI.; but in this particular it is subject to the greatest variation.

The leaf itself, as well as the petiole, is said to be sometimes prolonged into a tortuous appendage resembling the tendril; and similar transformations are sometimes exhibited by the peduncle and petals of the flower. In one species of vine mentioned by Malpighi, the extremity of the tendril, which is at first pointed, becomes gradually incurvated and reflected, and at length is formed into a roundish body, which is furnished with small papillæ, that yield a viscous fluid, by means of which it attaches itself to walls or wood, so strongly as not to be easily separated.

Of Roots. In dodder (*cuscuta*), small tubercles are formed on the stem, which, according to M. de Candolle, are so organized as to fix themselves on any other plant, and derive nourishment from it. (*Théorie Elément. de la Botanique*, p. 344.) For descriptions of the several varieties of these organs enumerated by botanists, and for the terms employed to express them, we must refer to their works.

Section III.

Of the Structure of Roots.

Form of Roots. Considered in relation to their general form, roots, says M. de Candolle, exhibit two very distinct appearances. Some roots have a conical trunk, simple or ramified, but springing always from a single base, and their radicle only elongates or ramifies; others spring always in a bundle, more or less marked, from a common base, which is so confounded with the neck of the plant that it is sometimes taken for the base of the stem, and sometimes for the trunk of the root. The first form of root is met with in the greater number of exogenous plants; the second occurs chiefly in the endogenous, and also in those exogenes which have fascicular roots.

Conical. Of the *conical* roots, some ramify greatly, and have numerous fibrous or capillary rootlets; others produce few or no branches, and are furnished with few fibrous roots. In the former class, the principal differences arise from the degree of ramification; in the latter, two varieties of form are very distinct—that of the carrot, named *fusiform*, from its tapering to a point, like a spindle—and that named *rapiform* by De Candolle, from the swollen form it assumes at its origin, and sudden shrinking to a point below, as in the turnip.

Fascicular. The *fascicular* roots present also many varieties of form: 1*st*, Those of the *Gramineæ*, in which each rootlet, though distinct at its birth, ramifies so much that the divisions resemble the fibrous productions of the preceding class: 2*dly*, Those of the hyacinth, in which many cylindrical rootlets spring from a common base, and descend nearly parallel, or with a slight divergence: 3*dly*, Those of the orchis, in which, besides cylindrical rootlets, there are others swollen into tubercles: 4*thly*, Those of Ranunculus, where all the fibres that spring from the base are more or less swollen, so as to form a bundle of oblong tubercles. Between all these distinct forms there are several intermediate varieties. Under the name of *tuberous* roots are included all those which have swellings in any part of their length, and that, too, whether they sprang originally from a single or common base. It may, however, be observed, that many tubercles which spring apparently from roots, are in reality productions from inferior branches of the stem, concealed beneath the soil, as M. Dunal first proved to be the fact in the potato. (*Organog. Végét.* tome i. p. 252.)

Parts of Roots. The root is held to consist of two parts; the main body with its branches, and the fibrous productions called capillary rootlets. These parts are commonly hid beneath the soil, but in some plants they are attached to rocks or stones, in others they are fixed in other vegetables. Some plants, again, have no fixed attachment, but float loosely on water; and others are considered to possess no root at all.

Structure. With respect to *structure*, the body of the root of trees, says Malpighi (*Anat. Plantar.* p. 145), may be regarded as an elongation of the trunk beneath the soil, being constructed of the same textures, disposed nearly in the same manner. In various herbaceous plants the root has been examined with much minuteness by Grew. (*Anat. of Plants*, book ii.) The cuticle, says he, is of different colours in different plants: sometimes its surface is smooth, at others rough; and its texture is either thin and transparent, or thick and opaque. At an early period the cuticle appears to be a continuation of that of the radicle, but afterwards seems to be derived from the bark. It is composed chiefly of cellular tissue, through which vessels are distributed in the direction of the length of the root. The existence of these vessels, though scarcely visible by the microscope, may be inferred from the fact that it is more difficult to tear the skin in a longitudinal than transverse direction. If, also, the skin be cut transversely, and then allowed to dry, all the parts where there are no vessels shrink below the surface of the cut end; but where there are vessels there is no shrinking. Or if, after making a transverse section of the root, the skin be pressed very gently with the edge of the nail, sap will sometimes arise from the skin, as from any other part where vessels are placed; which does not happen with fluids contained in the cellular tissue, unless the cells be broken. (*Ibid.* p. 62.)

Of the cuticle.

Of the bark. Beneath the cuticle lies the bark, which is found to differ very much, both in colour and thickness, in different plants; scarcely in some instances exceeding the skin in thickness, whilst in others it is thicker than the woody part of the root. It is composed of vascular fasciculi and cellular tissue, the cells of which are smaller than those in the trunk: these cells are generally of a spherical form, or nearly so, often transparent, but not visibly pervious into one another. In some roots the cellular tissue is disposed in rays extending from the inner to the outward edge of the bark; in others it extends only in part through the bark. The cells themselves are sometimes uniform, and sometimes they differ both in size and figure. They are often filled with lymph, or other matter. (*Ibid.* p. 64.)

In the cellular tissue vessels running lengthwise through the bark like small threads are observed; and in a transverse section the sap is seen to exude from them. They often form a net-work, and seem as if inosculated; but are only contiguous, like the braces in a drum. They are never single, but form clusters of 20 or more together: their form is cylindrical, and they are of the same size through their whole course. Some vessels frequently separate from a cluster and are transferred from place to place; but they never ramify so as to be successively propagated one from another. Their position in the bark is very various, forming sometimes a ring at its inner edge, and dispersed sometimes in clusters through it, or disposed in the form of lines or rays. The fluid they contain varies in colour and consistence in different plants, being sometimes thin and clear, sometimes thick and mucilaginous, often milky or resinous. Sometimes the fluids of the bark vary in the same root, which, when cut transversely, will yield both a limpid and milky sap. (*Ibid.* p. 67.)

Of the wood. The woody part of the root, like that of the trunk, is made up of cellular tissue and vessels. This tissue varies greatly in proportion in different roots, but is less abundant in the root than in the stem. It is disposed sometimes in rings, but oftener in lines and rays, like the transverse septa in the stem. Through this tissue two kinds of vessels are distributed, one containing a lymph, and the other being empty; whence they have been denominated by Grew the succiferous and air-vessels. In some roots these vessels are disposed in clusters or fasciculi; in others they form rings; and in others they have a radiated form. Both kinds are much intermixed, and everywhere surrounded by cellular tissue. The number of empty vessels is sometimes small and sometimes great;

Of Roots.

and the same may be said of their size, even in the same root. Malpighi, says Grew, has described them as being constructed of a thin transparent zone, of a silvery colour, having a spiral form; to which Grew adds, that the spiral zone is not a single piece of a flat form, but consists of two or more round and true fibres, not inosculated side to side, but knit together by other smaller fibres,—a construction similar to that which Kieser has since demonstrated. Their spiration, however, is better seen in the stem, and better in young parts than in old ones. Though these spiral vessels seemed empty, or containing only air, yet, says Grew, "whether these vessels may not, in some vegetables, and at some times, contain liquor, is doubtful." (*Ibid.* p. 74.)

Root of wormwood.

In illustration of the structure above stated, Grew exhibits, in twelve successive tables of his work, the external forms and internal structure of various roots. As a specimen of this structure, we have copied his representations of the root of wormwood. In fig. 13, Plate XL., is a delineation of a transverse section of this root, of its natural size; and in fig. 14 is a magnified representation of a portion of the same section, here presented on a reduced scale, in which A denotes the cuticle, B the bark, and C the wood. The smaller letter *a* indicates the ligneous rays formed by the vessels, and *b* the cellular tissue or transverse septa continuous with that of the bark. The dark spots in the bark are described by Grew as balsam vessels, intermingled with lymphæducts; and those in wood as the spiral or empty vessels. It will be seen that the vessels of the woody part are smallest at the centre, and gradually augment in size as they approach the circumference, as Kieser has since observed; and that, with the exception of a few vessels said to convey lymph, all those of the wood are considered as air-vessels, and therefore as possessing a spiral conformation. In his chapter on roots, Malpighi also frequently describes trachcæ as occurring in the dissections made by him of the roots of various plants.

Root of the gourd.

In fig. 21, Plate XL., is exhibited a horizontal section of the root of the gourd, of the natural size, as given by Kieser, representing four fasciculi of vessels, intercepted by cellular tissue. One of these fasciculi, consisting of 37 vessels, is represented in fig. 22, magnified 130 times. Of these vessels, the largest, as usual, are situated exteriorly, and they pretty regularly diminish in size as they approach the centre. Two of these vessels are nearly filled with vesicles, and the whole of them are generally of smaller size than those in the stem of the same plant. A vertical section of one of the largest vessels near the circumference, and of two of the smallest at the centre of this root, have been already exhibited in figure 19, Plate XXXVIII. They all belonged to the variety of punctuated spirals; so that all the vessels in the root of this plant, as well as in the stem, may be considered as possessing the spiral conformation.

Spiral vessels in roots.

To the testimony of Grew, Malpighi, and Kieser, as to the existence of *spiral* vessels in roots, we may add that of Du Hamel, who says that if a young root, as that of the horse-chesnut, be duly macerated in boiling water, and its bark afterwards removed, the ligneous portion will be found so tender as to be divisible into fine filaments; which filaments, when viewed with a microscope, will be found to be spiral vessels or tracheæ, which, he adds, might lead one to think that all the ligneous fibres are really spiral fibres, while they are yet tender. (*Phys. des Arb.* tome ii. p. 13, 14.) Mirbel and some other writers, however, deny altogether the existence of spiral vessels in the root; and M. de Candolle declares that one of the chief differences in structure between the stem and the root consists in the total absence of tracheæ in the latter. (*Organog. Végét.* tome i. p. 242.) Yielding credence, however, to the *positive* testimony of Grew, Malpighi, Du Hamel, and Kieser, rather than to the *negative* assertions of their opponents, we are disposed to conclude, that all the vessels which convey the ascending sap in the root possess, like those in the stem, a spiral structure.

It cannot fail to be observed also, in the sections of roots just exhibited, that the proportion of vessels to cells is much larger in the root than in the stem of herbs, and that consequently the cells are smaller and more compressed. The vessels occupy also the very centre of the root, to the exclusion of all cellular tissue, in the form of pith, in exogenous plants; but in the endogenous, the internal structure of the roots, as compared with that of the stem, is said to present no sensible difference. In exogenous plants, also, the diametral insertions, or septa, and the appearance of the bark, are as distinct in the root as in the stem; while in the endogenous the vessels and cells are intermingled through the entire root, as well as through the stem. In trees, the structure of the root is more distinct than in herbs, and still more nearly resembles that of the trunk.

In treating of the evolution of seeds, we exhibited several examples of the manner in which the fibrous or capillary rootlets spring from the trunk, or larger branches of the root. These rootlets are more simple in structure than buds, being made up chiefly of the ligneous portion of the plant. They are the organs which absorb nutriment from the earth; and hence, as Du Hamel observed, the earth is exhausted chiefly where these capillary rootlets are distributed, and not in the neighbourhood of the larger roots. On examining the roots of trees after severe winters, he often found the capillary rootlets dead; which led him to suppose that trees lose in the earth their capillary rootlets nearly as in the air they lose their leaves. He found, that even after slight frosts many of these rootlets were dead; and that, when the temperature became milder, new rootlets were developed, which abundantly replaced those destroyed. (*Phys. des Arb.* tome i. p. 89.)

All roots raised from seeds have a tap-root, that grows in length in proportion as the earth is easily penetrable. The seeds of the oak, sown in a deep and rich sand, have produced plants, says Du Hamel, the stems of which were only six inches in height, while the root extended nearly to four feet. If, however, the root meet below the surface with any obstacle that opposes its elongation, it then continues short, and subdivides into many lateral branches. This result may be also obtained by simply cutting the extremity of the root; for roots, as Du Hamel first ascertained by experiment, do not elongate but by their extremity. (*Phys. des Arb.* tome i. p. 83.) Hence, when injured by insects, or in any other way, so as to check its elongation, the root, by throwing out lateral branches, will often derive more nutriment by these new productions than it would have obtained by a single trunk.

Roots are provided through their whole extent with a quantity of germs, or a capacity of producing them, when placed in favourable circumstances; and this capacity is possessed also by the branch. If the branch of many trees be cut off and planted in the earth, it emits rootlets from its sides beneath the soil. If even the bark of a branch be removed so as to intercept the descending sap, and the part be then surrounded with moist earth, the upper portion of the divided bark will emit rootlets into the earth. The simple immersion of cuttings of the willow in water is sufficient to cause the production of rootlets,

which spring from the cutting, says Malpighi, just at the surface of the water, not below it. They appear at first like small tumours, and are composed of ligneous fibres and tracheæ, which gradually force their way through the bark. (*Anat. Plantar.* p. 146.)

In like manner, as a branch may thus be made to produce rootlets, so may a root be made to produce branches. If a root be cut off, or an incision be made in its bark, so as to intercept the descending sap, a swelling, or *bourrelet*, will form around the upper extremity, from which new rootlets will spring; or if this cut end be left exposed to the atmosphere, then, says Du Hamel (*Phys. des Arb.* tome i. p. 102), in place of rootlets, new shoots or branchlets will be developed. It is thus that many plants, as mint, which spread their roots horizontally, produce new stems from them when they happen to come sufficiently near to the surface. From the facts above stated, Du Hamel maintains that the tumour or enlargement (*bourrelet*) formed either on the cut stem or the root of a plant is essentially the same; that in both it contains germs proper for producing either branches or roots; and that the one or the other is developed, according as the *bourrelet* is exposed to the air or is placed in the earth. (*Phys. des Arbres*, tome i. p. 102.)

Others have maintained not only a perfect identity of structure between the root and branch, but also between the bud that gives origin to the branch, and the rootlet that springs from the root; and further, that they are convertible into each other. In proof of this it is alleged, that if a willow plant be bent down so that its head shall be fixed in the earth, it will soon push forth rootlets; and that if, after these are developed, the trunk with its former roots be raised so as to be exposed to the air, there will shortly be formed a new head, furnished with leaves and branches. These facts, however, prove only a substitution, and not a conversion, of these organs into one another; for the young buds of the head die when placed under the soil, and the new roots spring from points not previously occupied by buds; while, in like manner, all the young rootlets developed beneath the soil perish in the air, and new buds are produced from the older trunks of the root. In some plants the stem seems to perish, and the root in the following year produces a new stem; and from this it has been inferred that the root alone preserves the vitality of the individual: but the stem in these plants does not, says M. de Candolle, entirely perish; and in the phenomena exhibited by cuttings the contrary takes place, for the stem developes new roots. We ought therefore, says he, to regard the stem and the root as of equal importance. Their union constitutes the body of the plant. (*Organog. Végét.* tome i. p. 249.)

The knots or articulations in the stems of plants, by retarding the descent of the juices, favour the production of new parts; and according as the stem may be exposed to dryness or humidity, either branches or roots may be formed. Hence stems that have many knots most easily propagate by slips and layers; and fleshy plants, as the *Cactus*, which possess a thick and moist cellular tissue, have a disposition to propagate roots even in the open air. It is the same with roots possessing tubercles, which are a sort of magazines of nutrient matter, and possess, therefore, a singular aptitude for emitting new productions. (*Organog. Végét.* tome i. p. 248.)

We have already stated that roots grow in length, not by an extension of parts, but only by the addition of new matter to their extremity. This power of growth Du Hamel found to reside within two or three lines of the extremity, both in ligneous and herbaceous roots. (*Phys. des Arb.* tome i. p. 84.) It is chiefly by their extremities, also, that they absorb fluids; for Senebier found, that if the extremity of a root, as that of a carrot or radish, was immersed in water, the water was absorbed; whilst if the whole root, with the exception of the extremity, was immersed, little absorption took place;—results which have been confirmed by the experiments of Carradori. These facts have led M. de Candolle to consider the extremities of roots, and of all fibrous rootlets, as furnished with a peculiar hygroscopic power. This power he conceives to depend, as we before remarked, on the existence of a minute cellular structure at this part, to which structure he has given the name of spongioles (*spongiolæ*). These spongioles, according to him, are formed of a very compact cellular tissue, composed of roundish cells. He distinguishes several varieties of these organs, as the radical, the pistillary, and the seminal, according as they are seated at the extremities of the radical fibres, of the pistil, or in the coats of seeds. So great, he adds, is their absorbing power, that they absorb the colouring molecules of liquids, though these molecules will not enter the ordinary pores, which are infinitely greater in size. (*Organog. Végét.* tome i. chap. 7, p. 89.) In his 10th plate he exhibits the appearance of these spongioles in the radicles of *pandanus odoratissimus*, where they are better seen than in any other plant examined by him.

Of Roots.

Spongioles.

The nature and qualities of the soil exert a great influence on the form and size of roots. If the soil be free and pervious, the root often descends to a great depth in the form of a tap-root; but if it encounter obstacles which oppose its descent, it then continues short and divides into lateral branches. Roots also extend into the portions of soil that are richest, while the barren parts are nearly destitute of roots. (*Phys. des Arbres*, tome i. p. 82.)

Effects of soil on roots.

CHAP. III.

THE ANATOMY OF THE ORGANS OF VEGETABLES.

SECTION I.

Of the Structure of Buds.

In the preceding chapter we have described the larger and more permanent members of the plant. We have now to delineate the form and structure of organs, whose existence is of shorter duration, and which present a more diversified character. They may all be said either directly or indirectly to originate from buds, with which therefore we shall commence our descriptions.

Buds.

A bud, according to Gærtner, is an organic body, sprouting from the surface of a plant. In the beginning it is distinct from the proper and permanent members of the plant, but after some time becomes a part of it; or, if separated, is capable, by the increase of its own proper substance, of growing into a new plant, perfectly similar to its parent. (*De Fructib. Plantar.* p. 3.)

Definition.

Buds may in general be easily distinguished from seeds; but in some of the lower tribes of vegetables the conformity in external appearance and internal structure is said to be so great as to render this a matter of much difficulty.

Gærtner enumerates four species of buds, two of which are leafless, and two are provided with leaves or scales. The first, *propago*, is the most simple species of bud; it is leafless, and possesses different forms: sometimes it is entirely naked, and sometimes is inclosed in a bark-like case: it at length separates spontaneously from its parent, and is dispersed like a seed.

Species of buds.

Propago.

Of Buds.

Gongylus.

The second species is termed *gongylus:* it is described as a perfectly simple, leafless, somewhat globular and solid bud, concealed within the bark of the parent plant, and never separating spontaneously till the bark decays by age. It has a great affinity to the tuber of roots, but differs from it in not being a proper member of the plant, and in not possessing the principle of multiplication which resides in the tuber.

Bulbus.

The third species of bud is a compound germen, and named *bulbus.* Its figure is somewhat globular: it is nearly leafless, and formed of a very short keel (*carina*) and thick succulent scales, and at length separates spontaneously from its parent. Of this species there are two varieties, the one *solid,* constructed of a solid fleshy body, and having generally the rudiments of the new plant fixed outwardly upon it; the other *coated,* being formed of several concentric scales, in the centre of which the young plant is cherished.

Gemma.

The last species of bud, and that which is strictly so named, Gærtner denominates *gemma.* This is a bud composed of a subulate keel, and distinct herbaceous leaflets: it resembles a branch in miniature, and never separates spontaneously from its parent. It is named an *eye* (*oculus*) when it puts forth flowers alone, or flowers and leaves together; and simply a *gem* (*gemma*) when it is unfolded into leaves alone.

Of these several species, the last, *gemma,* is generally considered as alone entitled to the appellation of a true bud by those who consider scales and leaves as essential to its constitution; but this definition, says Gærtner, would exclude even bulbs, and it is better to derive our idea of a bud from a general agreement in properties, and particularly from similarity of origin in formation and evolution, than from the ever-varying condition of external form. The two former species of buds occur in the lower tribes of vegetables; the two latter are observed on the stems and branches, and roots of various plants. On the present occasion we shall notice the latter only.

Structure of bulbs.

That variety of bud which is called a *bulb,* and which springs from, or is variously attached to, the roots of many plants, has already been stated to exhibit considerable difference in structure. It is sometimes constructed of several thick scales or leaves enveloping each other, and is sometimes formed of a more continuous and solid substance. To the first description belongs the bulbous substance of the lily and tulip. Grew has given a section of the latter, made in the month of September. It displays the tunicated structure of the bulb, at the base and in the centre of which the young flower, destined to appear in the following spring, is observed. (See his *Anatomy of Plants,* table 63.) Of the tunicated variety, the common onion affords also a good example. The coats that compose its bulb are to be regarded as fleshy leaves, and the true root, according to Du Hamel, is the fleshy plate that supports the bulb, from which the rootlets spring. The common potato affords an example of the solid bulb, on whose surface numerous buds, all capable of producing entire plants, are seen. Botanists enumerate a great many other varieties of bulbs, for which we must refer to their writings; and to the works of Malpighi and Du Hamel for the anatomy of many of them.

Names of branch-buds.

The true bud of the stem and branch was distinguished by the ancients into two kinds, according as it produced either a leaf or a flower, and to it they assigned different names. "*Germen autem est id quòd ex ipsis arborum surculis primo vere exit, ex quo deinde folium producitur,*" says Pliny; and this he distinguishes from the flower-bud, "*nam gemma propriè floris est.*" By Grew the term *germen,* and by Malpighi the word *gemma,* is employed to denote each variety of bud. By Linnæus the term *germen* is used to denote, not the bud of a branch, but the rudiment of a seed; and not the rudiment of the seed only, but the organ also that contains it. The word *gemma* he uses to denote a bud. Gærtner adopts the word *germen* in a generic sense, to express every species of bud; and, with Malpighi and Linnæus, employs the term *gemma* as indicative of that species now under consideration. This, therefore, as the most generally received appellation, we shall in future employ.

During summer, says Du Hamel, buds are gradually formed in the axils of the leaves, viz. in the angle which the petiole forms with the branch. They are at first exceedingly minute; are seen in winter chiefly on the young branches, sometimes on the larger ones, and more rarely on the trunk. They exhibit different forms, according to the kind of tree that bears them, and are attached to it by a very short pedicle. Their position on the branch was considered by M. Bonnet to be reducible to five classes; sometimes they are situated on opposite sides of the branch, but placed alternately, and sometimes they are placed exactly opposite to each other. In other instances they form a kind of ring round the branch. Sometimes they have a spiral disposition, and at others constitute a sort of double spiral around the branch. In those cases where the buds stand opposite on the branch, the extremity of the branch is frequently terminated by three buds; but where the buds are only alternate, the young branch is commonly terminated by a single bud. In the pine the true buds are placed, not in the axils of the leaves, but at the extremity of the branch alone. Some buds stand out a considerable distance from the branch; others are placed in close contact with it; and these varieties occur sometimes on the same branch in regard to the buds that issue from its sides and extremity. The shape of buds is also very various—some being long and pointed, others short and round; some again are hairy, others smooth; some very small, and others large. (*Phys. des Arbres,* tome i. p. 99.)

Beside these varieties in position and form, which serve to distinguish the buds of different genera and species, there are also many sorts of buds to be observed on the same tree, whose characters are discoverable by their form. Those which are pointed usually produce leaves and branches, and from those which are large and rounder commonly proceed flowers. The former are named leaf or wood buds (*gemmæ foliiferæ*), the latter flower or fruit buds (*gemmæ floriferæ*): others which possess both leaves and flowers have been called mixed buds (*gemmæ mixtæ*). In some trees, as those of the apple and pear, two varieties of wood-buds occur, one of which is small, produces only a small bunch of leaves, and in the end becomes a fruit-bud; the other is larger, and gives origin to a branch.

As the rudiments of the flower appear in the bulb of roots the season before they are destined to bloom, so those of the leaf and the flower are distinguishable at the same period in the bud of the branch. They are to be perceived, says Du Hamel, in autumn, and continue to grow even during winter, appearing to be clandestinely formed in that season, when the movements of the sap seem to be suspended; and are thus prepared to shoot forth on the return of spring. It is, however, only in perennial plants that these phenomena are observed. Annual plants do not produce buds, and even those whose roots survive the fall of the stem produce buds only on their roots. (*Phys. des Arbres,* tome i. p. 103.)

Climate appears to exert the greatest influence on the formation and evolution of buds. In cold regions, as we

have just observed, the bud is formed many months before it is destined to shoot into a leaf or branch; but in warmer regions scarcely any interval occurs between the periods of formation and evolution. The buds, in such climates, are said to unfold themselves immediately from the bark into branches, without having remained in the form of buds for any length of time. Sometimes, in the milder seasons of our own climate, the evolution of buds rapidly succeeds to their formation, and the vegetative process with us emulates the productive powers of more favoured climes. In some examples, however, the specific characters of particular plants overcome these general tendencies of climate; and thus hot climates are said to possess some bud-bearing plants, and in colder climates there are a few shrubs which are said never to bud. (Willdenow's *Principles of Botany*, p. 273.) It seems, however, more correct to consider all plants as bearing buds, from which the branches, the leaves, and the flowers, successively proceed; and to say that in warm climates in general no suspension of the vegetative process occurs, as in cold ones, and no marked interval is observed, therefore, between the formation and evolution of buds. The few exceptions that occur respectively in warm and cold climates must be considered in reference to the specific characters of the individual plants. The process by which buds are actually formed has been called *Gemmation* or *Gemmification.*

Having made these few general remarks on the nature and formation of buds, we have next to exhibit a few examples of their structure and evolution, confining ourselves at present to a description of those which produce either branches or leaves. The mature bud consists of two parts; one that forms the new branch or leaf, and in the language of botanists may be termed *persistent;* the other serving only a temporary purpose, and falling when that purpose is accomplished. To the former may properly be applied the term *germ* or *gem*, and the latter, from its office, may be called *hybernaculum.* In its leading characters the bud bears a near analogy to the more perfect seed, for the germ very exactly resembles the plume; and the hybernaculum, as we shall see, in structure, office, and duration, approaches near to certain cotyledons.

The leaves or scales which constitute the hybernaculum, and which in future we shall denominate the *hybernacular leaves*, vary much in number, size, and figure, in different buds. Even in the same bud the inner ones are thinner, and much more tender and succulent, than the outer, and are besmeared with a viscid humour which intimately unites them; while the outer ones are commonly hard, hairy, and of a scaly texture. Like the cotyledonous leaves of seeds, those of the hybernacle sometimes grow for a certain time with the germ, and fall successively at periods more or less distant: they are also not less distinct in figure from those of the germ, than the leaves of the cotyledon are from those of the plume. This arises from the peculiarity in the distribution of their vessels, which do not spring from one common central trunk, as in ordinary leaves, but are derived from several distinct fasciculi at the base, like those of the cotyledonous leaf, as seen in that of the gourd, *a'*, fig. 13, Plate XXXIX. According to the manner in which they are disposed or folded up in the bud, botanists have assigned them different names, for an account of which we must refer to their writings. In the opinion of Du Hamel, they all derive their origin from the inner layer of the bark, of which they seem to be only a prolongation. (*Phys. des Arb.* tome i. p. 103.)

The *germ* of the bud, which is contained within and protected by these enveloping leaves, is composed of one or more leaves generally folded and curled, but in some instances open and expanded. At first they are very small, and their form is indistinct, so that the pedicle alone is distinctly visible; from which branch off the vessels that form the middle rib, and are afterwards expanded to construct the lobes of the leaf. From the figure which the germ possesses before its expansion being like that of a keel, its vascular portion at this period has been named *carina*, and its softer part *medulla* or pith.

With respect to the particular portion of the branch from which the germ internally derives its origin, opinions have much varied. Some have held that it proceeded from the pith alone; others from the first circle of vessels that immediately surrounds the pith; others from the tender wood alone; and others from the pith, the wood, and the bark conjointly. Grew held this latter opinion. (*Anat. of Plants*, p. 28.) Malpighi describes the germ as a tender, ligneous substance, formed of vessels and cellular tissue, and surrounded by its proper cortical texture. (*Anat. Plantar.* p. 45.) According to Du Hamel, it originates from the ligneous texture and the pith (*Phys. des Arbres*, tome i. p. 103); and Hill considered it to spring from the first circle of vessels alone, but not to carry with it any portion of the pith.

As every germ is composed of the cortical and ligneous textures, it may be said to originate in part from both, as all these writers seem to admit. Sometimes also the pith of the germ is continuous with that of the branch; but in other instances no such connection subsists, and there is nothing in the character of the pith of the trunk that renders it at all essential to the constitution of the germ. That in many instances, also, the germ springs from the first circle of vessels, is most certain; but it is not less certain that buds spring from trees long after this first circle of vessels has lost its vegetative power, or has been entirely destroyed.

In the oak Malpighi describes the entire bud as consisting of many scales enveloping each other, and forming an oval body. When evolution commences, these open and expand, and in part fall; but two generally remain and protect the springing germ for a long time. In fig. 15, Plate XL., is represented one of the hybernacular leaves *d* of the oak-bud, at the base of which the germ *e* is placed. The leaf *d* is described as possessing an oblong form, and is very evidently vascular; the germ is exceedingly small, and is represented as possessing at this period only one fasciculus of vessels. By degrees three fasciculi become apparent, which are continued through the germ, and form three pointed extremities, as in fig. 16. These parts augment, and the vascular fasciculi separate, so as to produce successively the appearances in fig. 17 and 18. At length the small curled leaf *f*, fig. 19, rising between the two hybernacular leaves *g g*, is seen to resemble the plume of the seed, and to possess a form altogether different from the enveloping leaves, which in appearance resemble more the cotyledonous leaves of certain seeds. In fig. 20 is given a vertical section of the germ, considerably magnified, in which *h* denotes the pith that occupies the centre: it is inclosed by vascular fasciculi, *i*, that send off through the bark ramifications to the several little processes that compose the serrated border of the leaf. (*Anat. Plantar.* tab. 10 and 14.)

But the method of nature in the evolution of buds, continues Malpighi, is not always the same; for the hybernacular leaves do not always waste and fall as those of the germ increase. On the contrary, in many trees, these leaves, especially those about the base of the bud, losing

Of Buds.

Origin of the germ.

Bud of the oak.

Other buds.

Of Buds.

their primary figure, assume new forms, and are converted into the permanent leaves with which the branch is adorned. Examples of this sort occur in laurel, in the apple-tree, the almond-tree, and many others. In other instances, as in the rose, the permanent leaves seem to be generated out of those of the hybernacle, from the apex of which they emerge; and gradually the latter is changed into a sort of petiole, to the sides of which two slender appendages, the remains of the former hybernacular leaf, adhere. Similar transformations are said to occur in many other plants.

Buds on the ends of branches,

The buds, such as they have been described, pullulate variously from the sides of stems and branches, and always above the insertion of the fallen leaves; but they spring also from their extremities, and produce the annual elongation of the branch or stem. The manner in which this takes place, and the appearance which the parts exhibit, have been well illustrated by the observations and dissections of M. du Hamel. In the evolution of the seed, the plume, as we have seen, rises above the earth, and produces the stem, which puts forth leaves. When these leaves fall in autumn, the stem continues, and is terminated by one or more buds. The roots, as already remarked, do not increase in length but at their extremity, and therefore never elongate after the smallest portion of their extremity has been cut off. It is not the same with branches; for the newly formed part of the young shoot actually elongates, especially at its extremity, where it is most succulent and tender,—less in the parts lower down, where it is harder,—and in its more ligneous parts not at all; as Du Hamel, by very simple and decisive experiments, ascertained. (*Phys. des Arbres*, tome ii. p. 14.)

in horse-chesnut:

The appearance, structure, and evolution of a bud, at the extremity of a branch of the horse-chesnut tree, are given by the same ingenious author, whose candour, ability, and success in the prosecution of these curious researches render him worthy to rank by the side of Malpighi and Grew. In fig 1, Plate XLI., is represented part of the annual shoot of this tree, terminated by its appropriate bud, formed in autumn, and which is the commencement of the next year's shoot. In fig. 2 a vertical section of the same bud is exhibited, in which the number and disposition of the hybernacular leaves that envelope and protect the germ in the centre are displayed. In the stem of the shoot the letter *a* denotes the pith, which is surrounded by the wood *b b*, and this again is covered by the bark *c c*. In fig. 3 is represented a section of part of the bud detached from the woody part of the shoot, and a little magnified, to show that the leaves of the *hybernaculum* take their origin from the inner portion of the bark.

their structure.

Proceeding next to the interior part of the bud, Du Hamel represents it as composed of numerous small leaves (fig. 4), which are more and more minute as we proceed inward, and are covered with fine hairs. In fig. 5 is a branch-bud of the peach, as seen in February, after all the enveloping scales have been removed. It is composed of greenish filaments, ranged nearly as they appear in the figure. When some of these filaments were detached and viewed with the microscope, they appeared toothed at the edges, as in fig. 6, and were covered with hairs. All these filaments were afterwards detached in order to disclose a small body lodged within them, and which appeared to consist of two small leaflets, folded and toothed at their edges, but not covered with hairs. It is represented in fig. 7. It occupied the centre of the shoot, and seemed to be connected with the pith.

In the next figure, 8, is represented the bud of the horse-chesnut in the state of evolution. The letters *d d* indicate the scales of the hybernaculum thrust aside by the shooting of the germ *e*, accompanied by two permanent leaves *f f*. The letter *g* denotes the place of a second bud. A vertical section of the same bud is shown in fig. 9, from which all the scaly envelopes have been removed It exhibits an entire shoot of one year's growth attached to part of one of two years. From *h* to *i* denotes the growth of two years, and from *i* to *k* that of one year, with the germ *k* in the centre, and the lateral leaves as in the preceding figure. The letter *l* marks the pith, *m m* the wood, and *n n* the bark of the young branch. From *l* to *n* the pith is white; from *n* to *o* greenish; and towards *i* it is of a brownish-red colour. From *i* to *k*, which marks the extent of the annual shoot, the pith is green and succulent, and at *p p* it is seen to be prolonged into the lateral branches. The wood of two years' growth, from *m* to *i*, is white, and forms a continuous tube round the pith, except where the branches go off. It is covered by another layer so thin as to be scarcely visible, but which will in the end become wood; and this layer is covered by the bark. The ligneous layer of the annual shoot appears to be a prolongation of the new layer of the older one, and, like it, possesses at first an herbaceous character. The cortical layer also seems to be a prolongation of that of the older shoot. As to the pith, though in both shoots it is continuous, it is to be observed that that of the older branch is white and dry, and that of the young shoot green and succulent. (*Phys. des Arbres*, tome i. p. 117.)

It is thus by the formation of a bud in autumn at the extremity of a branch, and the shooting and growth of that bud in the succeeding spring and summer, that the trunk of the tree and its branches are annually elongated. During the first season the shoot retains in great part its herbaceous characters, but in the second it becomes perfectly ligneous. In the axils of the permanent leaves of the young shoot, the rudiments of new buds become apparent, even in the first season.

It was before remarked that trees receive an additional circular layer every year, and that from these new layers buds successively spring, so that the earliest branches may contain as many ligneous layers as the trunk, and those of later formation a smaller number, according to the year in which they shot forth, and the circle of wood from which they sprang. Combining this growth in breadth with that in length, it will appear, says Du Hamel, that at the base and centre of a tree 100 years old there is wood of 100 years of age; whilst at the exterior part of the same tree, and at the extremities of its branches, there is wood of one year's age only. As the latitudinal growth was before illustrated by a diagram, a similar mode may be adopted to explain the longitudinal increase.

Let fig. 10, Plate XLI., represent in *q r* the ligneous portion of a tree that has proceeded from a seed in spring, and is observed in autumn. The following spring a second shoot proceeds from the bud *r*, which reaches as far as *s*; but at the same time there is a second ligneous layer formed on the first shoot *q r*, by which its thickness is proportionally augmented; and at the end of the second year the tree has the form and extent of the unshaded portion of the figure *q s*. The next spring the bud *s* opens and sends out another shoot to *t*; and ligneous layers are added as before to the two preceding shoots; and thus the tree is extended from *q* to *t*. The fourth year the same processes are repeated, and the tree extends from *q* to *w*; and each annual shoot, from the base to the summit of the figure, is seen to be composed successively of four, three, two, and lastly of one layer in thickness. This figure, therefore, illustrates the mode in which trees increase at the same time in height and breadth. The lig-

Of buds. neous layers may be compared to a series of cones which envelope each other, and which annually augment the diameter of the tree by the two thicknesses of the layers. It shows also that trees grow much more in height than in breadth, and that this growth is effected by the successive formation and evolution of buds at the extremity of the stem, precisely as the first shoot issues from the seed. (*Phys. des Arbres*, tome ii. p. 50.)

It is well known that if a bud be taken from one plant and inserted beneath the bark of a kindred species, it will grow, and retain in its new situation its original qualities and habits; or some buds, if directly planted in the earth and protected from too rapid exhalation, will produce a tree similar to the parent. Hence some writers, as Dr Darwin, have considered each bud as an individual plant, and that a tree, properly speaking, is a family or swarm of buds, which annually produce as many new plants. The bulbs produced beneath the soil by the tulip and many other plants resemble, in this respect, the buds produced in the atmosphere. Vegetables, therefore, are propagated by two methods—the oviparous, as by seeds, and the viviparous, as by buds and bulbs; and the individual plants, whether springing from seeds or from buds and bulbs, are all annual productions. The reproduction of plants, therefore, appears to be of two kinds, solitary and sexual; the former being accomplished by buds and bulbs, the latter by seeds, or through the agency of sexual intercourse.

Individuality of buds.

Section II.

Of the Structure of Leaves.

Leaves. These are organs of great importance in the vegetable economy: they are not however universal; for the *Cactus*, some species of *Schœnus*, and a few other plants, are considered to be destitute of leaves. Like other parts of the plant, they may be regarded with reference either to their external form or their internal structure. The former view belongs more especially to the botanist, who has very happily applied his descriptive language to portray the almost infinite diversity of figure, size, and character, which the leaves of different species of vegetables exhibit. On this branch of the subject we shall but lightly touch, recalling simply to notice the leading distinctions of the botanist, and such only of them as may appear to be more immediately connected with the *structure* of these organs.

Description. The leaves (*folia*) are distinguished and denominated according as they are *simple* or *compound*. Simple leaves are such as have only a single leaf on the stalk or petiole that supports them, and where all the parts of the leaf are continuous with one another. Compound leaves are those which are made up of more than one piece, or where the leaf is formed of parts or leaflets articulated together. In regard to their place, situation, and insertion, leaves are said to be *determinate*. By the *place* of a leaf is meant the part of the plant to which it is attached. By *situation* is understood the disposition of the leaves on the stem or branch, which corresponds to that of the buds. By *insertion* is expressed the mode of connection between the leaf and the stem or branch; and the *direction* of leaves is considered to bear reference to the position in which they stand to the stem.

Parts of leaves. The foregoing observations apply to leaves considered in connection with other members: when we regard them singly, we remark several parts which are common to almost all leaves, and to which particular names have been assigned. The part at which the leaf springs from the branch or stem, whether directly or by means of a petiole, is called the *base*, and the point opposed to this, the *apex*, of the leaf. The expanded portion is termed *limbus*, which has its two sides, faces, or surfaces, as they are indifferently called. The prominent lines that appear on these surfaces were named riblets (*costulæ*) by Malpighi, and have very improperly been called *nerves* by most writers; for the term *nerve* denotes an organ of a totally different nature, of which not even the existence has yet been demonstrated in any part of the vegetable system. To the line that circumscribes and forms the boundary of the leaf the term *margin* or border is commonly applied.

Of Leaves.

The *figure* of leaves exhibits the greatest diversity, to express which various terms are employed. Their *margin* also is either entire or variously fissured, notched, or toothed. Their *surfaces* are naked and smooth, or clothed with hairs and studded with excrescences; sometimes they are plain and flat, at others furrowed or plaited; and in all these particulars the opposite surfaces present also the greatest diversity. In *size*, leaves exhibit the most remarkable differences; and, with respect to *substance*, some are exceedingly thin, and have a membranous texture, others very thick, and of a fleshy nature. As to *colour*, they exhibit every shade of green, from the most gay and lively to the deepest and most obscure. In some the tint of colour approaches to blue, in others to red; and previous to their fall they all undergo those changes of colour which produce the diversified beauties of an autumnal scene. The period, however, at which this occurs is very different. Some leaves fall early, before the summer has passed, and are termed *caducous;* others retain their place till autumn, and then fall, and are named *deciduous;* others continue beyond the summer, and are styled *persistent;* and others, which have a still longer duration, are denominated *perennial*.

Their characters.

Origin from buds. In the preceding section on the structure of buds we exhibited the form and appearance of leaves in the earlier periods of their existence. They were shown to possess a very minute size, and to be curiously folded up and concealed within their various scales or coverings, which effectually protected them from the rigour of the winter season. The germ of the bud, from which the leaves originate, was stated to be composed of the same elementary parts as the stem and branch from which it sprang. From the ligneous ring in the annual shoot it derived its vessels, which, after having traversed obliquely the cortical layers, were prolonged into the pedicle by which it remained attached to the branch. This pedicle was continued to form the keel of the germ in its folded state; and, in its more expanded forms, to constitute the vascular riblets of the leaf. By subsequent growth it gradually extends and elongates, becomes more ligneous, and is formed at length into the slender stalk or petiole by which the leaf remains attached to the branch. (*Phys. des Arbres*, tome i. p. 123.)

Structure of the petiole. The vessels which are given off from the branch to form the petiole are not collected into one bundle, but constitute several fasciculi, which are disposed in different ways about the centre of the stalk. In some stalks there are three, in others five or six, and in others seven or more fasciculi, all placed, says Grew, either in an angular or circular posture, and at a greater or less distance from the centre. This centre is generally occupied by a pith, but sometimes it is hollow or tubular. In table 49 of the *Anatomy of Plants*, several transverse sections of the petioles of the leaves of different plants are given, exhibiting the different modes in which these fasciculi are dispersed through the cellular tissue that forms the greater portion of the stalk. In every instance the pith and bark

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of these petioles are represented as forming one continuous substance. In some plants the fasciculi of vessels that come off from the stem are not collected into a cylindrical figure, but, after being variously implicated with each other, expand at once into a leaf. Such leaves rise by a broad base, and, from being destitute of a petiole, are termed *sessile*, forming often a sort of sheath about the stem, of which several varieties are enumerated by botanists.

The petiole, as it springs from the branch, may be compared to a small stem, which at the basis of the leaf expands into numerous branches. Frequently it is continued through the centre of the leaf, forming its middle rib, and giving off in its course numerous branches. At other times, on reaching the base of the leaf, it separates at once into three or more equal portions, which form as many distinct leaves or parts of a leaf, supported by their respective petioles. The structure of the petiole is the same as that of the branch, being composed of the ligneous and cortical textures, in which sap and "proper vessels" are discoverable; and the whole is invested by the cuticle.

Structure of the leaf.

Where the petiole terminates, the proper or expanded portion of the leaf (*limbus*) commences, the figure of which is determined by the number and distribution of the vessels. These vessels divide and ramify in various modes, till at their termination they form a finely reticulated structure. In many recent leaves this structure is very visible; but when the softer parts are removed by spontaneous decomposition, the vascular system of the leaf remains nearly entire, and its extent and form are then more completely exposed. In fig. 11, Plate XLI., this distribution of the vessels is exhibited in a leaf of holly. From the central fasciculus branches are everywhere given off, which further subdivide, and form smaller ramifications, that terminate at length in a minutely reticulated structure. Around the margin of the leaf the vessels are continued, and at certain parts are prolonged into the thorns that bound the circumference of this leaf.

Vessels of the leaf.

In this and similar instances the vessels appear to be ramified out of greater into less; but, as already observed, this does not appear to be really the fact, the vessels being all of the same size everywhere in the leaf, and all continued through it, like so many distinct tubes. This structure Grew represents in a highly magnified view of the leaf of borage, in table 50 of his work; part of which is represented, on a reduced scale, in fig. 13, Plate XLI., designed to show that the ramified vessels *o* are all clusters of tubes of the same size, which, though they separate continually, and come into contact, are never produced or ramified one out of another. Neither do they ever inosculate or anastomose with each other, until, according to Grew, they come to their final distribution.

Its "proper vessels."

The vessels thus distributed through the leaf belong chiefly to the order of spiral vessels, as was shown by Grew in the leaf of the vine and many others; and, from the observations of Malpighi, Darwin, and Knight, already related, it appears that "proper vessels" are everywhere associated with them. It would seem, from the observations of Darwin, that these two orders of vessels communicate in the leaf by continuation of canal, as the arteries and veins do in animal bodies. In the stalk he considered them to be disposed in two concentric rings, the inner one of which carried out the sap to the leaves, and by the outer one it was returned to the bark. (*Phytologia*, p. 43 and 58.) In branches of the apple and horse-chesnut, Mr Knight also observed coloured fluids to rise through the vascular fasciculi in the petiole of the leaf. These fasciculi were surrounded by others free from colour, which conveyed a different fluid, and, on being traced down the stalk, were found to enter the inner bark, and to have no communication with those of the wood. The *returning* vessels he describes as being situated parallel to and surrounding those which carry up the sap. (*Phil. Trans.* 1801, p. 336.)

Cell tissue the

Beside the vascular system which, by its ramifications, forms the skeleton of the leaf, there is another structure that requires to be noticed. We have seen that the vessels, in their ultimate distribution, form a net-work more or less fine and minute in different leaves; so that a great number of intervascular spaces are produced. These spaces or areæ, says Malpighi, are occupied by cellular tissue, which springs from the vessels themselves, and seems to depend from them; and by its means the thickness of the leaf is formed. In the recent part of the borage leaf, represented in fig. 13, Plate XLI., this cellular structure, occupying the reticulated spaces formed by the vessels, is observed; but it is most clearly seen in thick leaves, when the cuticle has been removed, and the vessels in part dissected away. The cells or utricles which form this *parenchyma*, as it has been called, are of different figures, and are mutually contiguous; they are composed of a membrane formed into the shape of a little vesicle or bladder, from the middle of each of which a little vascular production issues; they are all connected with each other, and with the vascular system of the leaf. In fig. 12, Plate XLI., this cellular structure is represented in the leaf of *Cactus* by Malpighi, in which the oblong cells are described as proceeding from the central vessel, and mutually communicating with each other. (*Anat. Plantar.* p. 52.) A similar idea of the formation of the cells seems to have been entertained by De Saussure. In different leaves the cells possess very different sizes and forms. In the experiments of M. de la Baisse, they are said to have become tinged by coloured fluids conveyed from the vessels. Whether they communicate with each other is not known; but analogy, derived from other similar structures, would lead us to suppose that they communicate only with vessels, as seems to be the case in the cotyledonous leaf of the seed.

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M. de Candolle describes the leaf as consisting of a superior and inferior face, between which is an intermediate part, of very various thickness in different leaves, to which he gives the name of *mesophylle*, answering to the parenchyma of preceding writers. The leaf is formed, he says, by ramifications of the vessels, and by cellular tissue, which fills up the intervals of these ramifications. It probably comprehends two systems; one which, receiving the ascending sap, brings it into contact with the air, and permits the exhalation of its superfluous parts; the other a system which receives the elaborated sap, and reconducts it to the stem, where it serves for nutrition. Physiological phenomena, he adds, prove the existence of these two functions in leaves; but anatomy has not yet distinguished the organs by which they are accomplished. (*Organog. Végét.* tome i. p. 271, 273.) It has been before observed that M. de Candolle follows Kieser in regarding the alleged spaces between the cells, called intercellular canals, as the organs in which the vegetable fluids are conveyed; but the facts and arguments already stated establish, we think, with sufficient certainty, that, in the wood, the bark, and leaves, the sap is conveyed by appropriate vessels. The consistence of the leaf, continues M. de Candolle, depends much on the relative proportions of the cells and vessels that compose it. When the vessels are numerous, the cellular tissue is small in quantity, and the leaf is fibrous, firm, and thin; when, again, the vessels are few and distant, then

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the cells are more abundant, and the leaf is softer and more fleshy.

Differences in the surfaces of leaves.

The two surfaces of this organ often differ much in appearance and structure. On the upper surface the vessels are commonly but little prominent; it is therefore smoother, has but few hairs or pores, and is sometimes destitute of them. The lower surface, on the other hand, presents the vessels more prominent, and is furnished with hairs and pores much more abundantly. These differences are more particularly observed in the leaves of trees: in those of herbs the two surfaces more nearly resemble each other. In aquatic plants, though the upper surface is smooth and green, and the under one pale and rough, yet the former only, as being exposed to the atmosphere, is furnished with pores. It is to be remarked, however, that whether the two surfaces exhibit an aspect either very different or very similar, each seems destined to enjoy a special function. Hence, if the upper surface be turned downward, and the lower one upward, the leaf tends to resume its natural position; and if it be retained by force in a position not natural to it, it dies. (*Organog. Végét.* tome i. p. 274.)

Colouring matter of the leaf.

In the cellular tissue of herbaceous stems, and of all leaves, are contained small globules, which by the action of light are rendered green, and bestow on the plant its verdure. In the elongated cells of *Conferva reticulata* they are represented by Kieser as small green globules. (See Plate II. of his *Memoir.*) They are of a resinous nature, and have been named *chlorophylle* by chemists; but as a matter similar in composition is said to reside in the flower, M. de Candolle deems the foregoing name improper, and proposes to call this matter *chromule.* (*Ibid.* tome i. p. 19.)

Secreting organs.

In the substance of the leaf Malpighi describes small bags or follicles as existing between the cells and vessels, and which, in most leaves, yield a peculiar humour. They spring from the vessels, have a roundish or oblong form, and the lip that bounds their orifice is often furnished with hairs. This orifice points towards the upper surface of the leaf, or that which regards the heavens. In different leaves the follicles have different forms; and they afford a secretion which, adhering to the contiguous parts of the leaf, renders them shining. They are numerous in the leaf of the fig, lemon, orange, &c.; and are rendered more visible as the cellular tissue of the leaf wastes and dries. (*Anat. Plantar.* p. 52.)

Stipulæ and bracteæ.

There are other small leaves called *stipulæ* and *bracteæ*, which are attached to leaves and flowers, and are of some importance to the botanist. In the general features of their structure they resemble those already described.

Cuticle.

The whole structure of vessels and cells that compose the leaf is covered by a cuticle variously furnished with hairs and pores, and other appendages already described.

Section III.

Art. I.—*Of the Structure of Flowers.*

Definition of the flower.

The flower is that assemblage of organs which, by the mutual action they exert on each other, give origin to fruits and seeds. All the parts hitherto described contribute to the growth and perfection of the individual plant, and have been named the Nutritive or Conservative System; but the organs composing the flower are destined to continue the race, and from thence have been denominated the Reproductive Organs. In a limited sense the bud, produced by the conservative system, may be deemed a reproductive organ, since new individuals may successively be propagated from it; but after a certain period, plants thus produced seem to degenerate, and become incapable of producing fruit. Reproduction without fecundation presents no organic apparatus which is proper to it; but sexual reproduction, or that accomplished by fecundation, exhibits numerous and varied organs, which merit all our attention, not only because they exercise the principal functions of vegetation, but because, from the constancy and symmetry of their forms in the same species, though varied infinitely in different species, they afford the base on which Classification rests.

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Sexual organs in flowers, visible or invisible.

In relation to the organs of reproduction, vegetables, as before remarked, have been divided into two great classes: 1*st*, such as have flowers visible to the naked eye, and in which the sexual organs are distinct; 2*dly*, such as have flowers (if there be any) which can be rendered visible only by the microscope, and in which the sexual organs are not distinct. The former class, named phænogamous or phanerogamous, comprises all exogenous, and the greater part of endogenous plants; the latter, or cryptogamous division, comprehends some endogenous vascular plants, and all those which possess a simple cellular structure. At present we shall treat only of the first or flowering class.

Varieties in sexual organs.

The flower is essentially constituted by the presence of one of the two sexual organs, or of two re-united by a common support, with or without the exterior envelope destined to protect them. In some instances the flower bears only a male or female organ, and is then named unisexual; but more commonly these organs are present in the same flower, and it is then called hermaphrodite.

Description of sexual organs.

This unisexual flower, again, is simply male or female, according as it possesses either stamens only, or pistil only. In some instances, though the same plant bears both male and female organs, it is not hermaphrodite, since these organs occur in different flowers; in others, again, the male and female flowers exist only in different plants. Lastly, we sometimes find both male, female, and hermaphrodite flowers mingled together, either on the same or on different footstalks. The distinctions founded on this separation, re-union, and mixture of the sexual organs, have served as the basis of certain classes in the Linnæan system.

Sometimes the male or female organs alone, protected in a small scale, constitute the flower; but in general they are surrounded and protected by others, named the *corolla* and the *calix.* All these parts are commonly borne on a stalk called the *peduncle*, which, expanding at its extremity, forms the *receptacle*, or *torus* as it has been called, upon which all the parts above mentioned are supported. In fig. 1, Plate XLII., the sexual parts which constitute a perfect flower are exhibited. The letter *a* denotes the corolla, formed, in this flower, of six leaves called petals; *b* the stamens or male organs, which surround the pistil or female organ *c*; and *d* indicates the peduncle of the flower. In the next figure (fig. 2) the corolla has been removed, and the parts within are then more clearly seen. They now consist only of the sexual organs supported on the peduncle, and at their base are embraced by the calix *e*. The pistil, in the centre, is composed of three parts, viz. the ovarium *f*, the style *g*, and the stigma *h*; while each stamen consists only of two parts, the filament *i*, and the anther *k*, which latter contains the prolific matter named *pollen.* Such an assemblage of organs constitutes a perfect or complete flower; but it often happens, that in flowers where the sexual organs are present, one or other of the accessory organs is wanting; thus, in the tulip only one of the protecting envelopes is present, and botanists differ as to the name it should bear. Linnæus considers it as a corolla, because it is coloured like ordinary petals; but M. Jussieu regards it as a calix, from its analogy in structure and use to that organ.

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Peduncle of the flower.

The flower is sometimes attached immediately to the branch by its base, when it is termed *sessile;* but in general it is borne on a footstalk or peduncle. This peduncle of the flower, like the petiole of the leaf, is sometimes single and sometimes ramified: in the latter case its divisions take the name of pedicels.

Floral leaves or bracteæ.

Around the base of the flower we often meet with small leaves which, in size, colour, form, and consistence, differ from ordinary leaves. They are called *bracteæ*, and from the axils they form with the stem or branch the flower-buds often spring. From thus being the birth-place of the flower, which draws from them a great part of the nutrient matter, the bracteæ are smaller and more membranous than the ordinary leaves of the plant, and partake often of the colour of the flower. They must, however, be regarded as leaves, modified by the circumstances in which they grow, as is demonstrated by the fact, that examples frequently occur in which bracteæ are changed into true leaves. (De Candolle, *Organog. Végét.* tome i. p. 438–9.) When these bracteæ approximate so as to form a sort of envelope around the flower, they take the name of *involucrum*,—when this envelope becomes a sheath, it is named *spatha*,—in the *Gramineæ* it is termed *gluma*, &c.; of all which forms there are numerous modifications, to which botanists attach different names. The bracteæ approximate more or less in character to the calix, in proportion as they are coloured or exhibit the form of whorls; and the transition of the organs of vegetation into those of florescence is so gradual, says M. de Candolle, that the more we study it, the better do we comprehend that unity of composition which constitutes the base of philosophic organography. (*Organog. Végét.* tome i. p. 447.)

Flowers originate from buds.

The flower, as well as the leaf, originates from a bud, and in many respects the buds of flowers resemble those of leaves. They are covered and protected in the same manner, but they are generally larger, and have a more rounded form. They consist of two parts, the gem or eye (*oculus*), as it is sometimes called, and the *hybernaculum*, or protecting envelope. In some trees they spring from the extremity of particular branches; in others from the branches in common with the leaf-buds; and in others from the axils of the leaves. In fig. 3, Plate XLII., is a portion of the branch of the peach-tree, bearing two flower-buds *l l*, between which the smaller and more pointed leaf-bud *m* is placed.

Flower-buds formed in autumn.

Grew discovered and has exhibited many examples of the complete formation of the flower many months before it is destined to bloom. (*Anat. of Plants*, tables 63, 64.) Of this fact Du Hamel has also given several examples. In fig. 4 is a longitudinal section of the flower-bud of the peach-tree, made in the month of February, to show the complete formation of the stamens and pistils within the surrounding envelope of the bud. In fig. 5 is another representation of a similar bud, from which the enveloping scales have been removed: it displays the calix, which at this period completely envelopes the other parts of the flower. When the leaflets of the calix are separated, as is done in fig. 6, then the stamens and pistils are fully disclosed: the petals also of this flower were visible, but at this period were very small. Even the anthers were found to contain a fine dust, but no rudiment of the future embryo could be detected in the ovary. In the flower-bud of the pear, examined in February, the parts of fructification were also visible, but indistinct; a month later, all the parts were more advanced, and the stamens, petals, and pistils were distinct, and towards the end of March, even the rudiments of future seeds were visible in the base of the pistil. (*Phys. des Arbres*, tome i. p. 200.) Thus it appears that through the winter season the several parts of the flower are clandestinely formed, though still extremely minute. As they enlarge, their position within the bud is very various in different species: they gradually expand and form the perfect flower, whose several parts we have next briefly to describe.

The *peduncle* of the flower, by which all the other parts are connected with the stem or branch, is frequently single, but often divides into several parts or *pedicels*, as they are named, each of which supports one or more flowers. The modes in which the flowers are disposed on the pedicels have received different names from botanists, and to the general circumstance they assign the term *inflorescence*. The peduncle in structure resembles the stalk of the leaf, being formed, like it, of the several common textures. In size, in length, and other external characters, it exhibits all the varieties already noticed in the petiole of the leaf.

At the extremity of the peduncle is placed the flower-cup or *calix*, which has very different forms, and has received in consequence different names. Even in its most common forms it exhibits great variety. It is sometimes composed of a single piece, and has a tubular form; in others, of many pieces called *sepals* (*sepala*), which vary in number, position, and size, and for an account of which we must refer to the writers on botany. In some instances this organ falls when the fruit has set; in others it continues till the fruit is mature; and in others the fruit is formed within it, to which it becomes a permanent covering, and exercises the office of pericarp. The colour of the calix is commonly green, but sometimes partly red, or white, or yellow. In some flowers it is entirely wanting. From the dissections of Grew and Malpighi it appears, like the leaves, to be constructed of a cuticle, a pretty thick cellular tissue, and of vessels, all of which exist in the peduncle, and are derived from the common textures of the plant.

Above the calix, the *corolla*, the chief ornament of flowers, is borne. It is inclosed by the calix, but surrounds the interior parts of the flower, and is of every colour but green. It consists of one piece, or of several: these pieces are called *petals*, and according to the number of these pieces the corolla is variously denominated. The monopetalous corolla, or that composed of one piece, is also distinguished into several parts, expressive of form, position, or quality; and in the polypetalous variety, which consists of several pieces, each petal has its claw (*unguis*) situated at the base, and by which it is attached to the calix or receptacle, and its expanded part (*lamina*), which is of very various figure, size, and colour. At the base of the petal a tuft of hairs is often observed, and its surface is frequently covered with a fine down, or sometimes with jointed hairs bearing globulets, as occurs on leaves. With regard to structure, Malpighi describes it as composed of the same textures as the common leaf, as is distinctly visible in the thicker varieties of it. Grew showed it to possess *spiral* vessels,—a proof, as Du Hamel observes, that it is partly derived from the ligneous texture, since such vessels are not found in the bark. The odour these organs possess leads to the belief that they contain also a peculiar juice. (*Phys. des Arbres*, tome i. p. 215.)

The organ next to be noticed is the nectary (*nectarium*). In a strict sense this term designates any excretory gland which is situated on any one of the floral organs: and the juice it yields bears the name of *nectar*. The excretory glands observed on flowers deserve a common designation, because, whatever be their position on any part of the flower, whatever the nature of the juices of the plant, or whatever the size, form, or consistence of the gland itself, the secretion it yields is always saccha-

rine, and very similar in all known plants. In *regular* flowers the nectaries may occur on all the organs, symmetrically disposed. Their most common seat is the receptacle or torus. In some flowers, however, they are seated on the ovary, in others on the corolla, calix, stamens, &c. They have the form sometimes of distinct tubercles; but in different plants they exhibit various other forms. In *irregular* flowers the nectaries are not thus symmetrically placed, but are found on one part and not on the corresponding part of the same flower. Sometimes they supply the place of abortive stamens or pistils. The juice they secrete is greedily sought by insects. (*Organog. Végét.* tome i. p. 535.)

Art. II.—*Of the Sexual Organs of Flowers.*

Having exhibited this general view of the flower, we must now describe somewhat more particularly the forms, characters, and structure of its most important parts—the sexual organs.

The male organ or stamen consists, as before remarked, of two parts,—the anther, with the pollen it contains, and the filament on which the anther is borne. The filament, though a common, is not an essential part, and is sometimes wanting, when the stamen is said to be sessile: the perfection of the stamen resides, therefore, in the anther, and especially in the pollen it contains.

In regard to number, length, position, direction, &c. the stamens exhibit great diversity in different plants. The *number* of stamens in each flower varies from one to twenty or more; and on this number, progressively increasing in flowers truly hermaphrodite, the first ten classes in the Linnæan system are founded. In *length*, the stamens are equal or unequal; and this disproportion is sometimes symmetrical and sometimes not,—peculiarities which give rise to the formation of other classes in the Linnæan arrangement. In *position*, the stamens are sometimes opposed to the divisions of the petals, and sometimes they alternate with them. Sometimes, from being shorter, the stamens are wholly included within the corolla: in other instances they protrude beyond it. Their *direction* is erect, pendent, or horizontal; and their summit is variously inclined to or reflected from the centre of the flower. In some flowers the stamens are united by their filaments; in others by their anthers; and in others they are joined to and almost confounded with the pistil, giving origin, in their various modes and degrees of union, to the formation of other classes in the Linnæan system.

The *filament* which bears the anther is most commonly straight and filiform: sometimes, however, it is flattened or wedge-shaped, or awl-shaped. It is sometimes as small as a hair, sometimes large and flat like a petal, and its summit is either pointed or obtuse. To the summit the anther is commonly attached; but in some flowers this part is prolonged beyond the attachment of the anther. In structure, the filament resembles the corolla; and it often happens that these organs are transformed into one another. Thus the rose, in its wild state, has only five petals and many stamens; but by cultivation the stamens gradually degenerate into petals, and the flower becomes sterile. Malpighi describes the filaments as originating from the ligneous texture, being formed of spiral vessels and elongated cells; and as they are sometimes produced from elongated floral leaves (petals), they must necessarily, he adds, be formed of the same parts. (*Anat. Plantar.* p. 64.)

The *anther* is that essential part of the stamen that contains the fecundating matter. It is borne on the summit of the filament, and is generally formed of two small membranous sacs, attached immediately to each other, or united by an intermediate connecting body. Anthers, therefore, are generally bilocular; but in some plants there is only one sac or loculament, and in others as many as four. The sacs are either round, oval, or elongated: each sac commonly exhibits on one of its sides a longitudinal furrow: this side is properly called the face, and the part opposed to it the back, of the anther. The anther is attached to the summit of the filament, sometimes by its face, sometimes by its back, &c. In form, the anther is subject to great variety; and the two sacs that compose a bilocular anther are joined together in very different modes. In discharging the pollen the sacs open in different ways in different genera of plants, most commonly by the longitudinal furrow that runs along the face of the anther; but in some plants the opening, or dehiscence as it is called, is through two small holes or pores situated at the summit of the two sacs; and sometimes it is by a sort of little valves in some one or more parts of the anther. As the filaments of the stamens sometimes cohere, so likewise do the anthers, in a manner to form a sort of tube. In other plants the stamens, instead of being free or simply united together, coalesce so as to make one body with the pistil. The colour of the anther is often yellow, orange, violet, white, &c., but never green or truly blue.

The pollen.

The *pollen*, contained in the anthers, consists of numerous regularly figured small particles, which possess a very different figure, size, and colour in different plants. Many of their forms and sizes are delineated by Grew in table 58 of his *Anatomy of Plants*. In fig. 9, A, Plate XLII., copied from Grew, one of the filaments, bearing its anther, as it appears when detached from the pistil of the mallow, fig. 8, is exhibited. The particles of pollen are considerably magnified, and still more highly in fig. 9, B. In fig. 10 of the same plate, several representations of the forms of the pollen, as given by Du Hamel, are also exhibited. The number of these particles in each anther extends, it is said, from a few hundreds to many thousands. In the cell of the anther they are said to float in a viscous liquid, and to be nowhere attached to its sides, though it is probable they once were; and M. Turpin has even designated a salient point in each cell as the part which produced the pollen. (De Candolle's *Organog. Végét.* tome i. p. 465.)

In some flowers the pollen consists of transparent grains; in others they are of a white, purple, blue or brown, and more frequently of a yellow colour. Their surface is either smooth or rough, or covered sometimes with a viscous matter. When examined under the microscope at the period of maturity, they may be seen to burst, and yield a fluid, in which, according to Du Hamel, small granules are seen to float. This fluid is described as being thin, or viscid, or oily. If a grain of pollen be thrown on the surface of water, it may be seen to swell insensibly, and finally burst. At this moment a minute quantity of fluid matter escapes, which spreads on the surface of the water, and forms a sort of slight cloudiness. It is to this liquid matter that the fecundating property of the pollen has been attributed. (*Elemens de Botanique*, par Achille Richard, p. 199.) This fluid is said by Hedwig to be discharged at once on the bursting of its containing capsule; but Koelreuter considers it to be slowly transmitted through pores in the side, or hairs on the surface of the capsule.

Instead of being formed of distinct granules, the pollen is sometimes met with in a solid mass. In many genera of the families *Apocyneæ* and *Orchideæ*, all the pollen contained in one sac is united into one body, having the form of the containing sac; in other instances it forms smaller

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masses, and these are united by a sort of elastic net-work; while in others the masses are granular. The pollen is very inflammable, and in many plants its odour is said to bear a striking resemblance to the corresponding secretion in animals. (*Elemens de Botanique*, par Achille Richard, p. 200.)

Spontaneous motion in the pollen.

It has lately been said by some, that the particles contained in the grains of pollen exhibit spontaneous motions, like the spermatic animalcules of animals; others ascribe these motions to causes distinct from life; and others, though they allow similar motions to be exhibited by the molecules of unorganized matter, maintain, nevertheless, that in the granules of pollen they are independent of physical causes, and resemble the less rapid motions of some of the simplest animalcules of infusions.

The pistil.

The parts of the flower hitherto described are constructed, says Malpighi, with reference to the female organs, in which the seed, the last result sought by nature, is curiously formed and matured. This organ, called the pistil (*pistillum*), consists of three parts. These are represented in the pistil of the almond, fig. 11, Plate XLII., where the letter *p* indicates the stigma, *q* the style, and *r* the ovary. To this latter organ Malpighi and Grew gave the name of *uterus*, Linnæus that of *germen*, and Gærtner that of *ovarium*. In different plants the pistil exhibits great variety in form, size, number, and mode of attachment; upon which many of the *orders* in the Linnæan system are founded.

The ovarium.

The *ovarium* occupies almost always the inferior part of the pistil. It is the organ in which the seed is produced. When cut open it exhibits one or more cavities or cells, in which are contained the rudiments of the seeds or ovula; and it is in it that the change of the ovula into perfect seeds is accomplished. Its form is various, but most commonly ovoidal. It is seated commonly on the receptacle, together with the stamens; but frequently it is placed below the flower. Its cavity consists sometimes only of one cell or loculament, in which one or more ovula are found. More frequently there are two or more cells containing ovula: these are sometimes disposed in regular series, sometimes they are scattered and without order, and sometimes they are united to one another in a globular form. When these ovula are fecundated they become seeds; but in some plants a certain number are constantly abortive.

The style.

The *style* is a prolongation from the summit of the ovarium, and supports the stigma. It is commonly so situate in the flower as to be surrounded by the stamens; but sometimes it is entirely wanting, and the stigma is then said to be sessile. The ovary in different plants may be surmounted by one or more styles; while in other plants there is but one style to many ovaries. Most frequently the style occupies the summit of the ovary, but sometimes it springs from its side, and very rarely from its base. The forms of the style are numerous:—the most common is the filiform; but frequently it is thick, angulated, or club-shaped. It is commonly a hollow tube which communicates with the ovary: there is usually but one style to one ovary, but sometimes more. In some instances the pistils correspond in number with the loculaments into which the ovary is divided; in other instances every seed that is formed has its distinct pistil, while in other examples only one pistil is allotted to a great number of seeds. In some flowers the style is so connected with the ovary that it falls after fecundation; in others it continues after that event, and forms a part of the future fruit.

The stigma.

The *stigma*, which forms the summit of the pistil, sometimes terminates the style by an open mouth. Sometimes it appears like a small bud; in other instances it is variously divided or forked. Sometimes it is smooth; and is sometimes covered with hairs. The number of stigmata is determined by that of the styles, or divisions of the styles, and therefore varies from one to six or more in different plants. Sometimes the stigma is attached to the summit of the ovary, without the intervention of a style; but most frequently it is seated on the summit of the style, or occasionally attached to its side, or to that of the ovary.

In consistence, the stigma is thick and fleshy, or thin and membranous, or formed of small glandular bodies. In form, it varies exceedingly; and its surface is smooth, pubescent, or plumous, &c. In structure, it is ordinarily glandular; and at the period of fecundation its surface is rendered moist by a peculiar viscous matter. When the pollen falls on this matter, its grains burst, and the granules, called by some *favillæ*, are supposed to be absorbed by the spongioles seated in this part, and conveyed to the ovula by the vessels which form the pistillary cord, and thus accomplish their fecundation. M. Bulliard is said to have traced coloured liquors, previously absorbed by the stigma, along the vessels in the interior of the style, to the ovula contained in the cells of the ovary. (De Candolle, tome i. p. 480.) In many plants, however, either from the structure of the pistil, the nature of the pollen, or the circumstances in which fecundation is effected, the pollen seems never to come into contact with the ovula.

Section IV.

Of the Structure of Fruits and Formation of Seeds.

In the preceding section we described the structure of the flower antecedent to fructification: we have now to exhibit as concisely as possible the changes of form it undergoes after that event, and particularly as it regards the production of the seed.

After fecundation has been effected, the calix, corolla, stamens, and even style of the pistil, commonly fade and fall; the ovary alone remains, and undergoes very different changes of form in different plants. In the latter periods of its enlargement it is usually called *pericarp* (*pericarpium*), a term which is understood by botanists to apply also in certain cases to the calix, the corolla, or any other apparatus of organs that serves as a support and defence to the seed.

In its early state the ovary is described by Gærtner as possessing at first a simple cellular structure, which at a later period takes the form of distinct cavities or loculaments. Within these cavities minute globules are afterwards seen, which are the rudiments of future seeds. According to Mr R. Brown, the ovulum, in the unimpregnated ovarium, is attached only to a part of the membrane that lines its cell or internal cavity; but soon after fecundation in some cases, and still oftener during the growth of the seed, this membrane coheres so closely with the proper coat of the seed as to be no longer distinguishable or separable from it. In the ovarium of plants of the family *Compositæ* he observed two slender filiform cords, which, originating from the base of the ovulum or its short footstalk, ran up, and were more or less connected with the parietes of the ovarium, until they united at the top of its cavity immediately under the style, between which and the ovulum a connection was then formed. In some species of this family, as in *tussilago odorata*, these cords were easily separable from the ovarium, and could be removed entire along with the ovulum. These cords he regards rather as vessels conveying nutrient matter, than as organs by which impregnation was accomplished. A similar appearance of vascular cords con-

Fruits. necting the ovulum with the style was observed in the family *Brunonia;* and in certain liliaceous plants the bulb-like seeds, which separate from the plant before the embryo becomes visible, are supplied with distinct spiral vessels, which, entering at the umbilicus, ramify regularly through the fleshy mass, and appear to have a relation to the central cavity, where the embryo is afterwards formed. (*Linnæan Trans.* vol. xii.) Thus, then, the ovulum in the plant, like the egg in the animal, is, to a certain extent, produced without fecundation; but if that function be not performed, it soon degenerates and wastes. The progressive changes that occur in the ovary itself, and in its contained *ovula,* subsequent to impregnation, have been observed by Malpighi in several plants, whose observations, as they relate to the almond, we shall briefly detail.

In fig. 11, Plate XLII., is represented the pistil of the almond, as it appears soon after fecundation, in which the ovary *r* is seen to be somewhat enlarged, and has an oval form. In the next figure (fig. 12) a longitudinal section of the same pistil is exhibited, exposing the cavity of the ovary *s*, within which a small vesicle, *t*, is placed. As the ovary (fig. 13) enlarges, it becomes rounder, and its style is contorted and diminished in size. If in this stage it be laid open, as in fig. 14, its vessels, which in the peduncle *w* are disposed cylindrically, are observed to be dilated at the place of the calix *x*, and to give off branches to the ovary itself, and to the shell *y* that now begins to be formed within it. In the centre, the ovulum *z* is now seen to be much increased in size. All the parts continue to augment; the ovary (fig. 15) becomes rounder, and the appearance of the style is obliterated. On exposing its cavity in this stage, as in fig. 16, the ovulum *a'* in the centre is observed to be much increased, and the outer layer *b'* of the shelly covering that invests it now begins to harden. Such are the changes of form and structure exhibited by the ovary: we have next to trace more minutely those of the ovulum that is produced within it.

The earlier appearances of this body have been exhibited in fig. 12 and 14. When removed from its seat, a few days after fecundation has been accomplished, and viewed by a moderately magnifying power, it exhibits the form and appearance represented in fig. 17. Externally it is covered by a vascular tunic, *c'*, derived from the inner coat of the ovarium, a part of which coat adheres to it at *d'*. If in this stage the ovulum be laid open by a vertical section, as in fig. 18, it is seen to be composed of two tunics or sacs, one within the other; the inner one is filled with a cellular tissue, that contains a transparent juice. To this inner tunic the term *chorion* may be properly applied.

At a period a little later, when the ovulum is examined, a tubular body (*e'*, fig. 19) is observed to extend through the chorion or tunic last mentioned. Shortly after, this tube expands at its apex, and is found to contain a small vesicle. In fig. 20, which represents a section of the entire ovulum, the outer tunic, the chorion, and the tube *f* expanded at its apex, are exhibited. To it the appellation of *amnios* may be given; for it is the organ in which the *embryo,* or *corculum,* as at this early period it has been called, is first seen to emerge. Through several successive days the expanded portion of this tube enlarges and forms a sort of sac, which is filled with cellular tissue, and the summit of which, says Malpighi, the embryo is seen to occupy. In fig. 21 this amnios is separated from the other tunics, and at its summit the embryo *g'* is observed. If removed from its seat, the embryo presents the appearance *h'* (fig. 22), and when expanded, as in fig. 22, *i'*, is seen to consist of a body and two little wings.

Of Fruits. The ovulum in the almond, by Malpighi;

Having thus viewed the several parts of which the ovulum is composed in their separate state, let us next observe them in connection, and trace the series of appearances they exhibit, and the effects they produce on each other. In figure 23 is given a vertical section of the entire ovulum in a more advanced state. The outer coat *k'* still envelopes the others; the embryo *l'* occupies the summit of the amnios *m'*, whose lower part, still tubular, is continued through the chorion *n'*. In the next figure (fig. 24), from which the outer coat has been removed, the embryo *o'* and the amnios *p'* are represented as enlarged; but the chorion *q'* is partly exhausted of its juice, and has fallen down in a collapsed state. At this period the embryo, when separated from the amnios, has the form *r'*, fig. 25, and in its expanded state is represented by the letter *s'* of the same figure. The bulk of the embryo *t'*, fig. 26, continually augments, and encroaches on the capacity of the two tunics *v'*, *x'*, whose forms are constantly changing; and from being successively emptied of their juices, with which the embryo becomes filled, they are gradually pressed downward. At last the embryo *y'*, fig. 27, is so much augmented as to fill the cavity of the outer tunic; and by this time the amnios and chorion, exhausted of their fluids, exhibit the shrunk and corrugated forms in which they appear at the bottom of the figure. According to this representation, the outer tunic *k'*, fig. 23, derived from the ovary itself, and the fine membrane that immediately invests the embryo, form the only permanent coverings of the mature ovum or seed; for during the progress of formation the chorion and amnios (which are successively produced subsequent to fecundation) are again obliterated by the growth of the contained embryo. Malpighi describes the process of formation in many other seeds to be nearly similar; for his descriptions of which we must refer the reader to his work (*Anat. Plantar.* p. 71).

In the above descriptions of Malpighi, the several parts seem to be clearly exhibited, except in one important particular, namely, the situation and course of the *umbilical cord.* In almost every instance he designates the tube, which we have represented as the first form of the amnios, as the umbilical vessel (*vasculum umbilicale*), which the subsequent appearances it exhibits show to be erroneous. In the descriptions of Grew this deficiency in the representations of Malpighi is supplied. He has particularly observed the formation of the seed in the apricot, which in many respects resembles that of the almond; and we shall subjoin an abridged account of his observations.

In the apricot, by Grew;

In this fruit the pericarp that envelopes the seed is seen, in its mature state, to be composed of the pulpy part *a*, fig. 28, within which is the osseous envelope *b*, and at the centre the kernel or true seed *c*. At an early period both the pulp and stone are observed to consist of cellular tissue; and through the stone the vessels passing from the peduncle are continued. At the base of the figure the letter *d* denotes one fasciculus of vessels continued through the stone, and turning inward, where it reaches the apex of the seed. These vessels form the umbilical cord or seed-branch of Grew, while the fasciculus *e* that runs on the opposite side is continued to the flower. In fig. 29 a vertical section of the ovulum, as well as pericarp, is exhibited as it appears at a very early period; in which *f* denotes the pulp, *g* the stone through which the umbilical vessels pass and enter the outer tunic *h* of the ovulum, around which they make a ring. Within this tunic is another, *i*, filled with cellular tissue; and through its axis a small tube extends, at the apex of which the embryo *k* is first seen to emerge.

Of Fruits.

In fig. 30 these several parts of the ovulum are exhibited on a larger scale; the letter *l* denotes the outer tunic that immediately lines the stone; *m* the inner one, corresponding to the *chorion* of Malpighi; and *n* the tube answering to the *amnios* of the same author. Through the outer tunic Grew represents the umbilical vessels to pass and be continued to the middle tunic, the cavity of which is occupied by large cells that contain a pure lymph. At first this tunic is entire, but soon there appears in it the small duct *n*. This duct is not at first wider than a hair, and is dilated at each extremity into an oval cavity that contains a pure lymph. A few days after a soft node is seen to emerge in the upper cavity of this tube. This node (*o*, fig. 31) is described to possess a conical figure, and to be another tunic filled with very minute cells. It is at first entire, but when about the size of a carraway-seed it becomes a little hollowed near its apex, at which part the vessels enter and terminate in another very small node (fig. 32), which is the first appearance of the embryo of the seed. This embryo, when about one fifth part as big as a cheese-mite, begins to be distinguished by a little fissure, which marks the division of the lobes, as in fig. 33. When the lobes have increased, and are more fully formed, the node contracts at its base (fig. 34), indicating the place of the umbilical cord, which subsequently becomes the radicle of the seed. (*Anat. of Plants*, p. 209.)

This description corresponds nearly with that of Malpighi, as far as regards the situation and general form of the tunics, and the place in which the embryo is seen first to emerge. It also displays the course of the vessels to form the umbilical cord; but the growth of the embryo in this seed does not seem to produce the obliteration of some of the tunics in the manner delineated by Malpighi.

in the pear, by Du Hamel.

An example of a different kind is observed in the pear. Its structure has been described by Grew, and more minutely by Du Hamel. In its mature state it consists of a pulpy matter, in the centre of which are five loculaments that contain each two seeds. These appearances are exhibited in the transverse section, fig. 35; and in the longitudinal section, fig. 36, the seeds are further shown to be attached by a small umbilical cord. The pulp of the fruit is made up of a very fine cellular tissue, filled with the proper substance of the fruit, and is everywhere furnished with vessels. Through this pulpy matter a number of solid particles are met with, which are more particularly accumulated at the top and about the core. They are formed of an assemblage of small particles, of a stony consistence, with which a little knot of vessels (fig. 37) is everywhere connected. In fig. 38 is a thin transverse slice, showing the relative position of these stony particles, as indicated by the knots of vessels with which they are associated. The stony matter is not observed at an early period, but seems to be deposited from the juices in a more mature state.

By long maceration in water the pulpy matter is dissolved, and the vascular system is obtained separate. In the peduncle of the fruit fifteen principal fasciculi of vessels are contained. Ten of these are distributed to the seeds and flower, and the five others are dispersed through the pulp. This vascular structure is represented in fig. 39 after the removal of the pulpy part; the larger vessels embrace the core, and, after variously ramifying, terminate in the little vascular processes before described as connected with the stony matter of the pulp. In fig. 40 is represented one of the loculaments of the capsule, with the seed in it, receiving vessels from fasciculi continued from the peduncle; and in fig. 41 an entire seed is represented, and also a section of the same, in which the umbilical vessels that enter at the base are shown, as in other instances, to be continued beneath the tunic to the apex of the seed. (*Phys. des Arbres*, tome i. p. 242.)

Of the Ovum.

The last variety we shall notice in the formation of the seed is that of wheat (*triticum*), as given by Malpighi. In fig. 42 is represented the pistil of the flower of this plant, consisting of the ovarium *q*, the two styles *r*, and the feathered parts that form the stigmata. Previous to fecundation, the ovarium is found to contain a little vesicle, fig. 43, which is the rudiment of the future ovulum. After fecundation the styles soon fall, and the ovarium acquires a more pointed figure, as in fig. 44. If now it be opened, the little vesicle has changed its appearance, and contains within it another smaller vesicle, *u*, fig. 45. The ovarium continues to alter its shape, and assumes a more oblong form, fig. 46, and the appearance of styles is now quite obliterated. Gradually the little vesicle is formed into a small plantule, convex anteriorly, fig. 47, but more hollowed within, fig. 48, and which is situated at the base of the ovarium. The two portions thus described in figures 47 and 48 are the minute germ and cotyledon of this seed, which are represented in their appropriate place in fig. 49, in which the letter *x* denotes the germ, resting in the concavity of the cotyledon; *y* the albumen that forms the chief bulk of the seed; and *z* the ovarium, which in this seed continues permanent, and forms its outer tunic. (*Anat. Plantar.* p. 73.)

Opinions of Gærtner.

In his description of the progressive changes exhibited by the impregnated ovarium, Gærtner follows Malpighi and Grew, and refers to the figures given by those authors as illustrative of them. The liquor, however, in which the embryo is first seen, he confounds with the sac that contains it, calling it the amnios; but the term amnios designates the membrane or sac only, and not the fluid contained within it. Sometimes, he says, there is no proper sac for this fluid, but it is contained in the chorion, or in an appropriate cellular tissue. (*De Fructibus*, &c. tom. i. p. 60.) The changes in the ovary during the formation of the seed have likewise been observed by Mr Keith, of whose account of them agrees with that of Malpighi and Grew. (*System of Physiological Botany*, vol. ii. chap. 8.) Very recently, also, the same subject has occupied the attention of several foreign writers, and particularly of M. Mirbel, whose observations we shall briefly detail.

Mirbel.

According to M. Mirbel, little has been done to advance this part of physiology since the days of Grew and Malpighi, till the late observations of M. Schmitz and Mr R. Brown. The latter remarked that we ought not to judge of the structure of the ovulum from that of the developed seed. Acting on this idea, M. Mirbel applied himself to examine the ovarium, from the moment the ovulum begins to appear, and followed its progressive changes of development in plants of the same species. The ovulum at first he describes as a small pulpy excrescence of a conical shape, attached to the containing cell, and which does not appear to have any proper envelope or aperture of any kind. In plants whose ovaria produce many seeds, the ovula exhibit different degrees of development, according as they are nearer to or more distant from the vascular cords that supply nutriment. M. Schmitz, it is said, first discovered in the apex of each ovulum a small orifice or hole, which penetrates the two membranes or sacs, of which, at this early period, the ovulum is composed. To these sacs, which are placed one within the other, M. Mirbel has given the names of *primine* and *secondine*. The orifices at their apex, which at first form but one aperture externally, soon become more distinct from the enlargement of the parts within, and gradually a third membrane is seen to protrude through them. No sooner has it become visible in the form of a small pulp, than it begins,

Primine and secondine.

in some species, to dilate interiorly, so as to form a sac with very thin sides, which afterwards becomes blended with the secondine: in other species it protrudes to a considerable extent, and in a conical form, through the primine and secondine, which appear to invest it as the cup of the acorn embraces the kernel. In this state it is free at its apex, but is attached at its base to the secondine. To this sac the name of *tercine* has been given. These three tunics, it is said, appear together as soon as the development of the ovulum begins; the primine is never absent, and the same is probably the case with the tercine, nor has he ever missed the secondine but in a very few instances.

In addition to the three tunics or sacs just described, two others, named the *quartine* and *quintine*, successively appear. The former, says M. Mirbel, is not rare, but has escaped observation by being confounded with the tercine, from which, however, it differs both in its origin and mode of growth. On its first appearance it forms a cellular lining over the inner surface of the cavity of the ovulum. By degrees it separates, and continues attached only to the summit of that cavity. In this state it forms a close sac, and so continues in the ovula of some plants; while in those of others its cavity becomes filled with cellular tissue, and forms a pulpy mass.

The fifth envelope, or *quintine*, is always developed either within the tercine or quartine when they remain filled with cellular tissue. It is first seen in the centre of the sac like a fine tube, and is attached at one end to its summit, and at the other to its base. It begins to enlarge at the summit, and the embryo is almost simultaneously visible in it. As the enlargement proceeds downward, the quintine presses at all points on the sac that surrounds it, so as often to push down and occupy the place of the tercine or quartine. From the summit of the ovulum a very fine thread (*le suspenseur*) descends in the quintine, bearing at its extremity a globule, which is the nascent embryo. This quintine, adds M. Mirbel, answers to the vesicle called amnios by Malpighi.

The foregoing observations were made on the ovula of several plants, and in their more important points will be seen to correspond nearly with the descriptions of Malpighi and Grew. These latter authors have not so minutely examined the ovulum and its envelopes antecedent to fecundation; but after that event the chorion of Malpighi may be considered as answering to the tercine or quartine of Mirbel; for in the centre of this chorion the tube *e* (fig. 19, Plate XLII.) is seen to extend from the summit to the base, as in the tercine of Mirbel. The subsequent expansion of this tube at its summit (fig. 21), its gradual enlargement downwards, and the appearance of the embryo at its apex as described to occur in the quintine of Mirbel, are all exhibited in the amnios of Malpighi; as is also, in fig. 23, the pressure which this amnios makes on the surrounding sac. In the representations of these appearances given by Grew in figures 28 to 34 inclusive, Plate XLII., a similar series of changes is exhibited; and in what relates to the vascular connection of the ovum with the parent plant, he has anticipated most of the observations of those who have followed him. Thus, in fig. 28, 29, Plate XLII., he exhibits the course the vessels take after quitting the peduncle, and shows that they penetrate the several tunics to reach the point where the embryo, in the form of a small globule (fig. 32), is first seen to emerge; and in fig. 33 and 34 of the same plate he delineates the thread by which it is suspended.

Of Fruits.

According to M. Mirbel, the vessels which form the funiculus or cord enter the ovulum at the point afterwards called *hilum* in the mature seed, and terminate at a point in the inner tunic or membrane, to which the term *chalaza*, or internal umbilicus, has been applied. This point or chalaza in the inner tunic corresponds, he says, in the ovula of some plants with that of the hilum in the outer; but sometimes the vessels after their entrance are prolonged in the manner described by Grew, so that the place of the chalaza is opposite to that of the hilum. Wherever the chalaza may be situated, that part, Mirbel adds, is to be considered as the base of the seed. (*Recherches sur la Structure de l'Ovule Végétal*, par M. de Mirbel: *Annales des Sciences Naturelles*, Juillet 1829.)

Conclusion.

We have thus described in a general way the elementary organs that form the several textures of which the vegetable system, in phænogamous plants, is composed, and given examples of the various modes and proportions in which they combine for that purpose: we have next examined the structure of the mature seed, traced the changes of form observed in its evolution, and described the construction of the several members and organs that are successively produced: and, lastly, we have displayed the structure of the flower, and the formation and development of the ovum, from which a new seed originates, fitted to undergo and exhibit the same series of changes. The means and conditions required for the accomplishment of these changes, the circumstances in which they act, and the modes of their operation, belong to the department of PHYSIOLOGY, and will form the subjects of future consideration. (W.)

ANAXAGORAS, an eminent philosopher of antiquity, was born in the first year of the 70th Olympiad, or 500 years before Christ. Leaving his lands to be cultivated and enjoyed by his friends, Anaxagoras placed himself under the care of Anaximenes the Milesian. About the age of twenty he went to Athens and entered upon the study of philosophy, where he continued thirty years. Some suppose that he was the first disciple of the Ionian school, founded by Thales, a teacher of philosophy in Athens. When Anaxagoras assumed the character of a public teacher of philosophy, he quickly rose to high eminence, and produced many famous scholars, among whom were Euripides, Pericles, and Socrates. This philosopher contented himself with serving the republic in his own station, without interfering in any of the public affairs of the state. Both by the principles of wisdom which he inspired into the minds of the Athenian youth, and also by his daily advice in the most important affairs, particularly in the case of Pericles, he was of singular service to his country. But neither the friendship of Pericles, nor his own general disinterestedness of character, nor his immense stores of learning, could ward off the shafts of persecution. Cleo accused him of impiety, and the introduction of new opinions concerning the gods, because he taught that the sun was a burning mass of stone, or an inanimate fiery substance. By this opinion he was said to rob the sun of his divinity, because in the popular opinion he was deemed Apollo, one of the greatest deities. But although Cleo made religion the avowed cause of the accusation of Anaxagoras, it is highly probable that civil causes chiefly operated towards his condemnation. It is, however, abundantly evident that he did not hesitate to expose the vulgar superstitions on several occasions; but the evidence is not sufficient which pretends to prove

Anaxagoras || Anaxarchus.

that he was condemned for teaching the doctrine of a supreme intelligence, the creator of this world. His judges condemned him to death; but Pericles appearing in his defence, the sentence was changed from that of death to banishment and a pecuniary fine.

Expelled from Athens, Anaxagoras passed the remainder of his days at Lampsacus, teaching philosophy in the school of his deceased master Anaximenes, until the infirmities of nature terminated his life in the year 428 before Christ. Diogenes Laertius has collected, with little care and judgment, the details concerning this philosopher, which were scattered through various writings. It appears, that in the midst of some extravagant conceptions, Anaxagoras held opinions which indicate a considerable acquaintance with the laws of nature. His idea of the heavens seems to have been, that they were a solid vault, originally composed of stones, elevated from the earth by the violent motion of the ambient ether, inflamed by its heat, and by the circular motion of the heavens fixed in their respective places. The testimonies of several writers, among which is that of Xenophon, unite in proving that he considered the sun to be a large fiery stone; and Xenophon introduces Socrates as refuting that doctrine, and delivering an unfavourable opinion concerning his other writings. From his perceiving that the rainbow is the effect of the reflection of the solar rays from a dark cloud, and that wind is produced by the rarefaction, and sound by the percussion, of the air, he seems to have paid considerable attention to the phenomena of nature.

Our information is more correct concerning his opinions of the principles of nature and the origin of things. He imagined that in nature there are as many kinds of principles as there are species of compound bodies; and that the peculiar form of the primary particles of which any body is composed is the same with the quality of the compound body itself. For instance, he supposed that a piece of gold is composed of small particles which are themselves gold, and a bone of a great number of small bones: thus, according to Anaxagoras, bodies of every kind are generated from similar particles. That part of his system is more agreeable to reason which explains the active principle in nature. According to Diogenes Laertius, Anaxagoras taught that "the universe consists of small bodies composed of similar parts, and that mind is the beginning of motion." "He was the first," says the same writer, "who superadded mind to matter, opening his work in this pleasing and sublime language: 'All things were confused; then came mind and disposed them in order.'" Plato informs us that this philosopher taught the existence of a disposing mind, the cause of all things. Anaxagoras, according to Aristotle, taught that mind was "the cause of the world, and of all order; and that while all things else are compounded, this alone is pure and unmixed;" and that "he ascribes to this principle two powers—to know and to move—saying that mind put the universe in motion." Cicero expressly asserts that Anaxagoras was the first who taught that "the arrangement and order of all things was contrived and accomplished by the understanding and power of an infinite mind."

ANAXARCHUS, a Grecian philosopher, who lived under Philip of Macedon and Alexander, was born in Abdera, and belonged to the sect generally known by the name of the Eleatic. He is said to have been conducted in the progress of his early studies by the skilful hands of Diomenes of Smyrna and Metrodorus of Chios. He had the honour to be a companion of Alexander; and a few anecdotes transmitted to posterity concerning him render it evident that he treated him with the usual freedom of a friend. This philosopher candidly checked the vain-glory of Alexander, when, elated with pride, he aspired to the honours of divinity, by pointing to his finger when it bled, saying, "See the blood of a mortal, not of a god." It is likewise reported, that, on another occasion, while indulging immoderately at a banquet, he repeated a verse from Euripides, reminding Alexander of his mortality. It is, however, to be regretted, that the fidelity of the philosopher was wanting at the time when the mind of Alexander was tortured with remorse at having slain his friend Clitus; for it is reported that he on that occasion endeavoured to soothe the agitated mind of Alexander, by saying, that "kings, like the gods, could do no wrong." It is reported that Nicocreon, king of Cyprus, exposed him to the torture of being pounded in a mortar, and that he endured this torture with incredible patience; but as the same fact is reported of Zeno the Eleatic, there is reason to suppose that it is fabulous; and it may be added, that this narrative is inconsistent with the general character of Anaxarchus, who, on account of his easy and peaceable life, received the appellation of "The Fortunate."

ANAXIMANDER, a famous Greek philosopher, born at Miletus in the 42d Olympiad, in the time of Polycrates, tyrant of Samos. He was the first who publicly taught philosophy, and wrote upon philosophical subjects. He carried his researches into nature very far for the time in which he lived. It is said that he discovered the obliquity of the zodiac, was the first who published a geographical table, invented the gnomon, and set up the first sun-dial in an open place at Lacedemon. He taught that infinity of things was the principal and universal element; that this infinity always preserved its unity, but that its parts underwent changes; that all things came from it; and that all were about to return into it. According to all appearance, he meant by this obscure and indeterminate principle the chaos of the other philosophers. He asserted that there is an infinity of worlds; that the stars are composed of air and fire, which are carried in their spheres, and that these spheres are gods; and that the earth is placed in the midst of the universe, as in a common centre. He added, that infinite worlds were the product of infinity, and that corruption proceeded from separation.

ANAXIMANDRIANS, in the history of philosophy, the followers of Anaximander, the most ancient of the philosophical atheists, who admitted of no other substance in nature but matter.

ANAXIMENES, an eminent Greek philosopher, born at Miletus; the friend, scholar, and successor of Anaximander. He diffused some degree of light upon the obscurity of his master's system. He made the first principle of things to consist in the air, which he considered as immense or infinite, and to which he ascribed a perpetual motion. He asserted that all things which proceeded from it were definite and circumscribed; and that this air, therefore, was God, since the divine power resided in it and agitated it. Coldness and moisture, heat and motion, rendered it visible, and dressed it in different forms, according to the different degrees of its condensation. All the elements thus proceed from heat and cold. The earth was, in his opinion, one continued flat surface.

ANAXIMENES, a Greek historian and rhetorician, was born at Lampsacus about 580 years before Christ. Some writers ascribe to him the Treatise on the Principles of Rhetoric, which bears the name of Aristotle; and it is reported that Philip of Macedon invited him to his court to instruct his son Alexander in that science. He attended Alexander in his expedition against Persia. The history of Philip, of Alexander, and likewise twelve books

on the early history of Greece, were the productions of his pen, but none of them has been preserved.

ANBAR, a town of Asia, in Arabian Irak, situated on the Euphrates. It was taken by Caled, lieutenant of the caliph Omar, in the year 632, and it was rebuilt by the first caliph of the Abapides. It is 35 miles west of Bagdad. Long. 43. 2. E. Lat. 33. 15. N. It is also the name of a town of Great Bukharia, in the province of Balk, 70 miles S. S. W. of Balk. Long. 64. 18. E. Lat. 36. N.

ANBERTKEND, in the eastern language, a celebrated book of the Bramins, wherein the Indian philosophy and religion are contained. The word in its literal sense denotes the cistern wherein is the water of life. The Anbertkend is divided into 50 beths or discourses, each of which consists of 10 chapters. It has been translated from the original Indian into Arabic, under the title of *Morat al Maani*, q. d. the marrow of intelligence.

ANCARANO, a town of Italy, in the marquisate of Ancona. Long. 14. 54. E. Lat. 42. 48. N.

ANCASTER, a town of Lincolnshire, situated in long. 30. W. lat. 52. 30. N. It gives title of duke to the noble family of Bertie.

ANCENIS, an arrondissement in the department of Morbihan, in France. The extent is 310 square miles, or 197,120 acres. It is divided into five cantons, and these into 28 communes, having a population of 40,992. The chief place, of the same name, contains a population of 3295 inhabitants.

ANCESTORS, those from whom a person is descended in a straight line. The word is derived from the Latin *ancessor*, contracted from *antecessor*, goer before. Many nations have paid honours to their ancestors. It was properly the departed souls of their forefathers that the Romans worshipped under the denominations of *lares*, *lemures*, and *household gods*. Hence the ancient tombs were a kind of temples, or rather altars, whereon oblations were made by the kindred of the deceased.

ANCHISES, in fabulous history, a Trojan prince, descended from Dardanus and the son of Capys. Venus made love to him in the form of a beautiful nymph, and bore him Æneas, the hero of Virgil's Æneid.

ANCHOR, in *Navigation*, from the Greek αγκυρα, which Vossius thinks is from ογκη, a *crook* or *hook*, an instrument of iron or other heavy material used for holding ships in any situation in which they may be required to lie, and preventing them from drifting by the winds or tides, by the currents of rivers, or any other cause. This is done by the anchor, after it is let down from the ship by means of the cable, fixing itself into the ground, and there holding the vessel fast. The anchor is thus obviously an implement of the first importance in navigation, and one on which too much attention cannot be bestowed in its manufacture and proper construction, seeing that on it depends entirely the safety of the vessel in storms. The invention of so necessary an instrument remounts, as may be supposed, to the remotest antiquity. The most ancient anchors consisted merely of large stones, or baskets full of stones, or sacks filled with sand, or logs of wood loaded with lead. Of this kind were the anchors of the ancient Greeks, which, according to Apollonius Rhodius and Stephen of Byzantium, were formed of stone; and Athenæus states that they were sometimes made of wood. These sorts of anchors retained the vessel merely by their inertia, and by the friction along the bottom. Iron was afterwards introduced for the construction of anchors, and also the grand improvement of forming them with teeth or flukes to fasten themselves into the bottom; whence the words οδοντες and *dentes* are frequently taken for anchors in the Greek and Latin poets. The invention of the teeth is ascribed by Pliny to the Tuscans; but Pausanias gives the merit to Midas, king of Phrygia. Originally there was only one fluke or tooth, whence anchors were called ετεροστομοι; but shortly afterwards the second was added, according to Pliny, by Eupalamus, or, according to Strabo, by Anacharsis the Scythian philosopher. The anchors with two teeth were called αμφιβολοι or αμφιστομοι, and from ancient monuments appear to have been much the same with those used in our days, only the stock is wanting in them all. Every ship had several anchors, the largest of which, corresponding to our bower or sheet anchor, was never used but in extreme danger, and was hence peculiarly termed ιερα or *sacra*; whence the proverb *sacram anchoram solvere*, as flying to the last refuge.

Anchor.

Anchors are now universally made of wrought iron, excepting in Spain and some parts of the South Sea, where they are made of copper. One essential quality in every anchor is a sufficient weight to fix itself in the bottom; and this has been determined by practice for different anchors, and for vessels of different sizes.

Weight of anchors of different sizes.

Large vessels have several anchors of different sizes, and stowed in different parts of the vessel. These are distinguished by different names, viz. the *sheet-anchor*, the largest of all, and which is only let down in cases of danger, or when the vessel is riding in heavy gales of wind. The *bower-anchors*, of which there are sometimes two or three, are nearly of the same size with the sheet, and are distinguished into best bower, small bower, and spare anchor. The *stream-anchor* is of a much smaller size than the above, used only for riding in rivers or moderate streams. It is not generally above one fourth or one fifth of the weight of the others. Lastly, the *kedge-anchor* is still smaller, being only about one half of the stream-anchor, and is only used when kedging in a river. In ships of war the sheet-anchor is stowed upon the after-part of the fore-channel, on the larboard side, with the stock vertical, and one of the flukes resting on the gang-way. The bower-anchor hangs to the cat-head, with the other extremity fixed up to the anchor-boards; and the spare anchor is stowed away on the starboard fore-channel. Ships of the largest class carry seven or eight anchors, and the smallest class, as brigs, cutters, and schooners, three or four.

The weight of anchors for different vessels is allowed by the tonnage. A pretty near rule for the principal anchor of ordinary-sized vessels is to allow for the cwts. in the anchor one twentieth of the tonnage. Thus a vessel of 400 tons would require her principal anchor to be 20 cwts., or according to the following tables:—

Merchant Vessels. Tonnage.	Weight of Anchor.	Vessels of War.	Weight of Anchor.
20 tons	1 cwt.	20 guns	25 cwt.
35	$1\frac{3}{4}$	24	30
50	$2\frac{3}{4}$	28	31
65	$3\frac{1}{2}$	32	35
70	$4\frac{1}{2}$	36	40
80	5	38	44
100	$5\frac{3}{4}$	40	46
130	7	44	48
160	8	50	50
190	$9\frac{1}{2}$	64	57
220	$10\frac{1}{2}$	74	68
250	12	80	76
280	14	90	84
320	$15\frac{1}{2}$	100	90
380	$17\frac{1}{2}$		
430	20		
480	21		
520	25		
720	33		

Anchor.

Form and dimensions of anchors.

Next to the weight, the form of the anchor, and the proportions of the different parts, are of great importance. The most general form, and that which has indeed been almost universally adopted all over the world, is that represented at Plate XLIII. fig. 1, and in section at Plate XLIV. fig. 1 and 3, consisting of the two hooked arms for penetrating and fixing themselves into the soil; the long bar or shank for attaching the cable; and the stock, which is attached to the extremity of the shank, and serves to direct one of the points downwards into the soil. The weight of the anchor then causes the point to penetrate more or less according to the softness or hardness of the bottom; and the action of the vessel on the cable, instead of loosening the anchor, tends rather, by the hooked shape of the arms, to fix these deeper and firmer into the soil; so that the vessel is held quite fast, unless either the cable itself gives way, or any part of the anchor, or the anchor is dragged along owing to the looseness of the soil. The *shank* of the anchor is made long, in order that the stock may have the greater power in directing either the one or the other of the arms downwards. It also serves, when the anchor is to be weighed, as a lever for starting it out of its place; the cable drawing upwards by the extremity, and turning the whole round the point of the fluke. The one end of the shank is made square, to receive and hold the stock steadily in its place without turning. To keep the stock also from shifting along the shank, there are raised on it from the solid iron, or welded on it, two square tenon-like projections, called nuts. The length of the square of the shank is about one sixth of the whole length of the shaft, and the thickness about one twentieth. From the end of this square the shank increases in thickness, tapering towards the extremity, where the arms are attached: in all this part it is either made wholly round, or with a flat on opposite sides, or polygonal. The end next the stock is called the *small round*. The other extremity, where the arms and the shank unite, is called the *crown*, and the point of the angle between the arms and the shank the *throat*. Here the thickness of the shank is from $1\frac{1}{2}$ inch in small anchors, to 3 inches in large ones, greater than at the small round. A distance equal to that between the throat of one arm and its bill is marked on the shank from the place where it joins the arms, and is called the *trend*. Near the extremity of the square part of the shank is the hole for receiving the ring for the cable, which is about half the thickness of the small round, and the diameter nearly equal to the length of the square. The ring used to be invariably lapped with cordage, to prevent the cable from chafing against the iron; but since the introduction of iron cables, this has become no longer necessary.

The *arms* make an angle of about 56° with the shank. They are made either round or polygonal like the shank, about half their length. The remainder of the arm consists of three parts, the *blade*, the *palm*, and the *bill*, Plate XLIV. fig. 1, and in another view at fig. 2. The blade is merely the continuation of the arm in a square form. The palm or fluke is a broad, flat, triangular plate, fixed on the inside of the blade, the use of which is, by exposing a broad surface, to take a firmer hold of the ground. The bill is the extremity of the arm, where it is tapered nearly to a point, for the purpose of penetrating more readily into the soil. In some cases the arm is made quite straight from the crown to the bill; in others, and particularly in small anchors, the interior half is made with the arch of a circle, as at fig. 3. The whole length of the arm is nearly half the length of the round part of the shank. It tapers slightly from the throat to the blade, where it is about the same thickness with the small round of the shank. The palm is about one third of this in thickness, and the breadth of its base is nearly equal to its length.

The *stock* of the anchor, represented at fig. 4, is made of oak, consisting of two beams embracing the square, and firmly united by iron bolts and hoops. The length of the stock is rather greater than that of the shank, the thickness in the middle about one twelfth of its length, and tapering to about the half of this at the extremities, the taper being all on the under surface next the arms, and the other quite straight. The taper is not quite regular. It commences at about half the breadth of the stock from the shank, and continues in one straight line to the extremity. The beams of the stock are hooped close together at the extremities, but gradually open towards the centre, that, in case of the wood shrinking, the hoops may be driven farther in, fig. 5. Of late years the stock has frequently been made of wrought iron, the same as the anchor; and this plan is now very generally followed, particularly with smaller anchors. It has this advantage, that the stock can be at any time taken out and laid parallel with the anchor, which is very convenient for stowage. The iron stock, fig. 6, consists merely of a long round bar, about half the diameter of the anchor at the square. Instead of embracing the anchor, like the wood, it goes through a hole in the square, which is swelled out to receive it. It has a shoulder in the middle, which rests against the square, and a key driven through a hole in the stock on the other side keeps it fast. When the stock is to be taken out of its place, the key is driven out: the stock then slides through the hole in the shank, and by means of a bend at its extremity, it is laid parallel with the shank.

The operation of the anchor is easily understood. Being let down by means of the cable, the weight of the arms throws them downwards, and keeps the whole in a vertical position until it reaches the ground, where it lights upon the crown; and then falling over, the position of the stock at right angles to the arms, and its length and height, together with the weight of the cable, are sure to throw it with one of the arms pointed into the ground, if it does not take this situation of itself. This effect is aided by the anchor descending quickly—and hence it must be allowed to descend freely; for which purpose, in *throwing* or *casting* the anchor, the cable is arranged along the deck in long coils, called by the seamen a French flake, one end being attached to the anchor and the other secured on deck. Every thing being prepared, the lashing of the anchor is cast off, and the men stand ready to let go; and when this word is given by the person in command, the fastenings are all cast off, and the anchor, falling into the sea, descends with rapidity, and draws the cable after it so violently, that it is often necessary to throw water on the hause holes to prevent their taking fire. When the anchor, again, is to be removed from its situation and drawn up into the vessel, the operation is termed *weighing;* which requires often a very heavy purchase, particularly at starting. This is obtained by means of the windlass, round which the cable is wound, and a number of hands applied to work it. With cables which are too large to be wound round a windlass, a smaller rope is used, termed a messenger, which being attached to the cable at different points, and wound round the windlass, serves to bring the cable forward. But since the introduction of chain-cables this contrivance is not so much required.

When the anchor is brought above water, a tackle is got upon the shank, just within the flukes, and the arms are hove up so as to lie upon the gunnel and anchor-boards; the stock is then made vertical by heaving upon it with a

tackle, in which position it is secured by the stock-lashing. The ring is fastened to the cathead by the stopper, one end of which is fastened round the cathead, and the other is brought through the ring, then over the stopper-cleat, and is belayed round a timber head. To secure the shank at the arms, a chain called the shank painter-chain is passed round it, and fastened to a timber head.

The following table contains the dimensions of the parts of anchors of different weights. The letters G. L. denote the greatest and least diameters or breadths.

Weights.	SHANK. Sizes. Length.	Throat. G.	Throat. L.	Trend. G.	Trend. L.	Small. G.	Small. L.	SQUARE. Sizes. Length.	Breadth at the Root. G.	Breadth at the Root. L.	Hole from End.	RING. Extreme Diameter. G.	Extreme Diameter. L.	Diameter of Iron.	ARMS. Sizes. Length.	Throat. G.	Throat. L.	Small. G.	Small. L.	PALMS. Length.	Breadth.	Thickness. Middle.	Thickness. Edge.
Cwt.	ft. in.	in.	in.	in.	in.	in.	in.	ft. in.	in.	in.	in.	ft. in.	ft. in.	in.	ft. in.	in.	in.	in.	in.	ft. in.	ft. in.	in.	in.
$2\frac{1}{4}$	6 0	$3\frac{7}{8}$	$2\frac{5}{8}$	4	$2\frac{1}{2}$	$2\frac{7}{8}$	2	1 4	$3\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{2}$	0 $10\frac{1}{2}$	0 $10\frac{1}{2}$	$1\frac{3}{8}$	2 0	$4\frac{1}{8}$	$2\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{2}$	0 $11\frac{1}{2}$	0 11	$7\frac{1}{8}$	$\frac{5}{8}$
$7\frac{1}{8}$	8 $6\frac{1}{2}$	$5\frac{1}{2}$	$3\frac{7}{8}$	$5\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{3}{8}$	3	2 0	$4\frac{1}{2}$	$2\frac{7}{8}$	4	1 $4\frac{1}{2}$	1 $4\frac{1}{2}$	$2\frac{1}{4}$	3 0	$5\frac{3}{4}$	$3\frac{7}{8}$	$4\frac{3}{4}$	$3\frac{1}{8}$	1 6	1 5	$1\frac{3}{8}$	1
8	8 $7\frac{1}{2}$	$5\frac{1}{2}$	$3\frac{7}{8}$	$5\frac{3}{8}$	$3\frac{5}{8}$	$4\frac{1}{4}$	3	2 1	$4\frac{5}{8}$	3	4	1 $4\frac{1}{2}$	1 $4\frac{1}{2}$	$2\frac{1}{4}$	3 0	$5\frac{3}{4}$	$3\frac{7}{8}$	$4\frac{3}{4}$	$3\frac{1}{8}$	1 6	1 5	$1\frac{3}{8}$	1
$28\frac{1}{2}$	14 1	$8\frac{3}{4}$	$6\frac{1}{4}$	$8\frac{1}{8}$	$5\frac{3}{4}$	$6\frac{1}{8}$	$4\frac{3}{4}$	2 6	$6\frac{1}{2}$	5	$4\frac{3}{4}$	2 0	1 10	$3\frac{1}{8}$	4 4	9	$6\frac{5}{8}$	7	$5\frac{3}{8}$	2 0	2 0	$2\frac{1}{4}$	$1\frac{1}{2}$
$49\frac{1}{2}$	15 7	$9\frac{3}{8}$	$8\frac{1}{8}$	$8\frac{1}{2}$	$6\frac{5}{8}$	$7\frac{1}{8}$	$5\frac{5}{8}$	2 0	$7\frac{1}{4}$	6	5	2 7	2 $3\frac{1}{2}$	$3\frac{5}{8}$	5 0	$10\frac{3}{4}$	$7\frac{7}{8}$	$8\frac{3}{8}$	$6\frac{7}{8}$	2 7	2 7	$2\frac{7}{8}$	$1\frac{7}{8}$
$73\frac{3}{4}$	17 0	$11\frac{3}{8}$	$8\frac{7}{8}$	$11\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{7}{8}$	$6\frac{7}{8}$	3 1	$8\frac{7}{8}$	$7\frac{1}{8}$	7	2 $10\frac{1}{2}$	2 $8\frac{1}{2}$	$4\frac{1}{8}$	6 0	$11\frac{3}{4}$	$8\frac{7}{8}$	$9\frac{3}{4}$	$7\frac{3}{4}$	3 $0\frac{1}{2}$	3 $0\frac{1}{2}$	$2\frac{3}{4}$	$1\frac{7}{8}$
$90\frac{3}{4}$	18 5	$11\frac{7}{8}$	$10\frac{1}{4}$	$11\frac{5}{8}$	10	$9\frac{1}{8}$	$7\frac{1}{2}$	3 6	10	$8\frac{1}{4}$	8	3 2	2 10	$4\frac{3}{4}$	6 $2\frac{1}{2}$	13	$9\frac{1}{4}$	$10\frac{1}{8}$	$8\frac{5}{8}$	3 2	3 $0\frac{1}{2}$	$3\frac{1}{4}$	2
94	19 3	$12\frac{1}{4}$	$9\frac{3}{4}$	$11\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{1}{4}$	$7\frac{5}{8}$	3 $7\frac{1}{2}$	$9\frac{1}{4}$	$7\frac{7}{8}$	6	3 2	2 10	$4\frac{3}{4}$	6 $4\frac{1}{2}$	$13\frac{1}{8}$	$9\frac{3}{4}$	$10\frac{3}{4}$	$8\frac{5}{8}$	3 $3\frac{1}{4}$	3 2	$3\frac{3}{8}$	$2\frac{1}{4}$

Besides anchors of the common construction, there are various others of different forms occasionally in use. Small vessels often employ what are termed *grapnels*, which are merely common anchors with four or more arms instead of two, as shown in fig. 7. Following out the same principle, we have the *mushroom* anchor, fig. 8, much employed in the East Indies, to secure the vessels which they term grabs. In this the arms are continued in one segment of a sphere all round; it hence requires no stock, as it takes the ground in any direction. Attempts have frequently been made to introduce anchors with only one arm, but hitherto without any decisive result. A patent for an anchor of this kind, as represented at Plate XLIII. fig. 2, was taken out by Mr Stuard, which has attracted some notice. "In order," says he, in the Specification of his patent, "that this anchor may be sure to fall the right way with the fluke downwards, I would have the shank very short, whereby, when suspended by the cable, it will cant the most, and when it has hold in the ground, the ship will ride safer; as a long shank has more power to loosen and break the ground, and is more likely to be bent or broken from its hold. Let the form of the shank and arm of the anchor be as AA, fig. 2; and, that the parts may be stronger than if made separately and shut together, I would have the bars which compose them in one length, so that there be no weld or joining in the whole length of the shank and arm. The hole B is to receive the ring for the cable, and the hole C is for the stock, which is composed of a wrought-iron bolt, as A, fig. 3, covered with cast-iron at its ends, BB. The palm to be in shape as D, fig. 2, and shown detached in fig. 4, made either entirely of cast-iron, or a cast-iron shell filled with lead, which is of much more specific gravity than iron. The back of the palm to be formed either with concave surfaces or flat surfaces, making angles at the centre. The anchor is also to have a small shackle, fixed on the bend of the shank and arm, as at E, fig. 2, for the buoy-rope to be made fast to. The shank may be made without the hole C, and the hole B made octagonal; or if round, it should have a small fillet projecting from the stock, and a small cavity on one side of the hole B to receive it, thus to prevent the stock from turning round; and instead of a ring for the cable, to have a shackle fitted on the stock, on each side of the shank; and, that the shackle may not turn on the stock and fall too low, a stop is to be fixed on each side at the upper end of the shank." (See *Repertory of Arts*, &c. vol. v.)

New mooring anchor.

Mooring Anchors are those which are fixed in certain situations in harbours or roadsteads, and to which any of the vessels frequenting the place may be secured. As these are no way limited as to weight like portable anchors, they often consist merely of a large block of stone, such as at fig. 9, with an inner ring fixed in the middle of the upper side; or several such stones may be fastened together so as to act as one mass. Mooring anchors are also often made by choosing one of the largest anchors used for first-rate ships, weighing 80 cwt., and by bending one of the arms close down upon the shank, to prevent it catching the cable or mooring chains whilst the ships are riding. These anchors are lowered down into the water with a very strong iron mooring chain fastened to the ring, to which the ships are fastened: they are usually made from such as are damaged in one of the flukes or arms. A new kind of mooring anchor of cast-iron was described by Mr Hemman of Chatham, to the *Society for the Encouragement of Arts, &c.*, in 1809, for which he obtained a silver medal from the society. AA, fig. 5, Plate XLIII., represents the palm or heavy part of the anchor, made very massive of cast-iron, and of considerable breadth, so that the edge B, or part which enters the ground, may have a great hold; the shank C is made also of cast-iron, and fixed firmly to the head by passing through it, and has a small ring at *a*, where the buoy-rope is fixed; the other end of the shank goes through the stock DD, which is formed of two large wooden beams hooped together in the same manner as the stocks for common anchors; the end of the shank projects through the stock, and has a strong wrought-iron shackle E fixed to it by a bolt passing through both, and with this the mooring chain is connected. The great advantage of this over the common mooring anchors arises from its great weight and breadth of

Anchor.

edge to act against the ground; and, being made of cast-iron, it is also more durable. A pair of these anchors, weighing 150 cwt. each, will, with the mooring chains, cost about L.874 less than a pair of the common anchors, which, with their chains, cost L.2472. (See *Transactions of the Society for the Encouragement of Arts, &c.* vol. xxviii.) Another form of this mooring anchor is shown at fig. 10.

Floating anchor.

This is the name given to a sort of anchor which has often been proposed, but never reduced to practice, for preventing a vessel from drifting, in cases where the great depth of the sea precludes the use of the cable and ordinary anchor. The plan suggested by Dr Franklin seems the most rational. This anchor consisted of two cross bars, secured together in the middle, and having sailcloth fastened to them in the shape of a parallelogram. To the centre of these bars the cable was attached, and being thrown overboard, it was thought the resistance of so large a surface would at least check the rapidity of the ship's motion.

Fabrication of anchors.

In fabricating anchors the different parts are first forged separately, as the square, the ring, the shank, the arms, and the palms. The square is then welded on to the extremity of the shank, and the ring let through its hole, and then the joining welded. The arms are then welded on to the shank, and the palms to the arms. The forging of such heavy masses of iron as the larger anchors are composed of, and the welding of the parts together, is one of the most difficult operations in smithery, and one which it has required all the ingenuity of our most skilful artists, and a long course of experience, to bring to its present perfection. The shank forms the largest mass. It is formed of an assemblage of smaller bars, united together by welding them into solid masses. This mode is preferable to making a single bar of sufficient size by the forge-hammer in the original preparation of the iron, because the compounded bar is not liable to have any internal flaws or cracks, or at least they will not be in a transverse direction; for the bars are all examined separately before uniting them, and any which are imperfect are rejected; if, therefore, after the welding, any cracks are left between the bars, they must be in the length of the anchor, and will not deduct so materially from the strength of the whole.

Formerly the small bars were laid together, so as to form a square, as in fig. 11; and round these, smaller bars were piled to complete the circle; and then this circle was surrounded by bars to the number of 30 or 40, all arranged round the circle, and packed together like the staves of a cask; iron hoops were then driven over all to keep them together, and the whole faggot thus united was welded by repeated heats and elaborate hammering, applied successively from the one end to the other of the bar. Great difficulty was always found in heating and welding together the inside or central bars along with the external ring, the latter becoming quite overheated before the former could be brought up to the welding point. In these circumstances it became very difficult to weld the bar equally, so as to give it all the strength of which the material was susceptible; and it was often thought sufficient to weld merely the outside ring, so as to form a perfect covering or case for the inside bars, which were left in a raw or unwelded state. A more perfect method of welding the heavy bars of the anchor together was introduced some years ago at Plymouth, by Mr Perring, clerk of the cheque. This consists in using bars the whole breadth of the shank laid on one another, as at fig. 12, and hooped. These are then welded together in two heats, until the whole is one compact body, which is readily done in this manner, without overworking any part of the iron. If the bars do not extend the whole breadth, they are laid so as to break joint.

The *arms* are formed and welded together into a mass in the same manner as the shank. They are then united to the extremity of the shank, by shutting or welding them all together at the crown, for which purpose the end of the shank is formed with a flatted surface or scarf, having a shoulder on each side, and the ends of the arms with similar scarfs, as at fig. 13. A more perfect method of uniting the arms and the shank, by Mr Perring, is, to form the crown separately of bars similarly to the shank, uniting them into one for half the length only, and the other half remaining split in two, as at fig. 14; then opening this by means of two rods, welded on the ends on purpose, bending them round two steady pins, as at fig. 15, so as to form part of the arms, as at fig. 16. The angular opening being then filled up by a piece formed of bars properly welded, another piece half the thickness of the arms is bent over and united with the others, so as together to form the crown and part of the arms on each side. In this manner a much firmer joint is formed than by mere scarfing. The crown piece being thus formed, the shank is welded to one extremity, and the two arms and the blades to the two others. The *blades* of the arms are formed in a manner similar to the shank. The palms are made by laying a number of plates one on another, and welding them all properly together, after which the palms are shut on upon the blades.

After the different parts of the anchor are thus forged and welded together, they are all smoothed and finished off by working with hammers till the metal becomes quite cold. This process, besides improving greatly the appearance of the anchor, is of real use in hardening the surface, and causing it to withstand better the corrosion of the sea-water.

The following is a more particular account of the operations of the anchor-smith on a large scale. The hearth AA of the anchor-smith's forge, see fig. 6, Plate XLIII., is built of brick-work raised about 6 or 9 inches above the ground, and 6 or 7 feet square; in the centre is a large cavity, to contain the fire; at the back of the hearth a vertical brick wall B is erected, supporting and forming one side of the chimney, which is little more than a dome placed over the hearth, and opening at the top with a low chimney to carry off the smoke. Behind the wall the bellows CD are placed; the noses of the pipes being about the level of the hearth, and coming through the wall, which at that part is defended from the action of the fire by a facing of fire-stone. In this fire-stone the tue-iron is fixed; it is a tube made of wrought iron, and very thick in the substance, that it may not burn away in the fire: the pipes of the bellows are inserted in the tue-iron, and thus convey the stream of air into the centre of the fire.

The bellows are not like those which ordinary smiths make use of; but two large pairs of single bellows CD are placed horizontally by the side of each other, the pipes of both being inserted into the same tue-iron, and directed to blow to the same focus in the centre of the fire: these bellows are exactly like those in use for domestic purposes, which only throw out air when the upper board is pressed down. The two are worked alternately by means of chains *c d* attached to the ends of the upper boards, and united to the end of the working levers HI, placed over each pair of bellows. From the opposite extremities of these levers other chains *e f* are extended to the opposite side of a long lever GG, which moves upon the pivots of a vertical axis E, and is loaded at the ends by heavy weights, to give it *momentum*. Now, two or more men pushing in opposite directions can give it a motion backwards and forwards, and by the communication of the chains and upper levers HI, they will alternately lift up the upper boards CD of the bellows, which being sufficiently loaded, will subside themselves, and force their contents

of air into the fire. The men who work the lever G are aided by six or eight more, who place themselves upon the board of one pair of bellows, and as soon as it subsides, they step upon the other pair, which also sinks, and then they return: they have ropes suspended from the roof to enable them to lift themselves, and mount from one bellows upon the other with more ease. The common tue-iron, which is simply a cone of wrought-iron, set with clay into fire-stone, composing the back of the hearth, is very soon burnt by the great heat. The most improved forges, therefore, are now furnished with what is called the water tue-iron, which is made hollow, and water introduced into it to keep it cool. For this purpose two cones are formed of thick iron plate, each with a small aperture at the vertex; these, when put one into the other, are welded together at their bases and their points, so as to form one cone, which is hollow, with a small space all round; two pipes communicate with the hollow, one bringing a continual supply of cold water, and the other conveying away that which is heated by the fire. By this means the tue-iron is kept cool, and can never acquire such a degree of heat as to be burned away: this tue-iron is set with fire-clay into a frame of cast-iron, built up in the brick-work of the wall B.

The anvil K is only a cubic block of cast-iron, placed on the ground much lower than the ordinary smith's anvil; because, as the anchor-smiths always strike by swinging their hammers over their heads, at arms' length, they have more force when the work lies low on the ground than if raised up. At a distance of eight or nine feet from the hearth AA a strong crane-gib LM is erected, so as to turn freely upon the vertical post M. It has no tackle, but the upper beam L, which must be horizontal, has a large iron loop *n* hung upon it, with a roller *o*, which admits it to run freely backwards and forwards upon the beam: the lower end of the loop suspends the anchor; therefore, by moving the rollers along the beam of the gib, and by turning the gib round on its pivots, the anchor can be placed in any position in the fire or upon the anvil. To give motion to the roller *o*, a rack *p* is connected with it; and this is moved by a pinion upon the axis of the wheel *t*, which has an endless rope hanging down, so that a labourer can reach it, and thus remove the anchor nearer or farther from the centre, however great its weight may be. The workmen employ scarcely any other tools than their sledge-hammers, and a few large punches, cutting chisels, and sets or prints, which, when urged by the hammers, will give any particular figure to the work: the hammers are of the largest kind, and weigh from 14 to 18 pounds, according to the strength of the workmen. In the Royal dock-yard great use is made of a stamping machine, which the workmen call *Hercules*, and which is very similar to the machine for driving piles. A heavy iron weight N, guided like the ram of the pile engine, is drawn up by the strength of several men, and let fall upon the anchor, to weld the bars, in the same manner as by a forge-hammer. The machine is erected on a large block of stone, which supports the anvil O: two square iron bars PP are fixed on each side of the anvil, in a vertical position, the angles of the bars being placed towards each other. These vertical bars are eight or nine feet high, and are fixed at the top to a beam in the roof of the building in which the machine is placed. The ram N, which weighs 4½ cwt., is fitted to slide up and down between the bars P, having notches in its sides, which receive the angles of the bars: it is drawn up by a rope passing over an iron pulley Q, mounted upon pivots above the top of the vertical bars; and the rope has eight or ten small ones R spliced into it, for as many men to act together (which they do by a motion similar to that of ringing), to elevate the ram, and let it fall upon the iron placed upon the anvil O. The Hercules is placed in the same sweep of the crane as the anvil K, so that the iron can be conveyed to either with equal ease.

The first step in making the different parts of the anchor is to assemble or faggot the bars. For the centre of the mass which is to make the shank, four large bars are first laid together; then upon the flat sides of the square so formed smaller bars are arranged, to make it up to a circle. The number is various, but in large anchors six or eight bars are laid on every side. This circle is surrounded by a number of bars arranged like the staves of a cask: as many as 36 are often used, and they form a complete case for the others. The ends are made up by short bars to a square figure. The faggot is finished by driving iron hoops upon it at sufficient distances; see W in the figure; and it is suspended from the crane in such a manner that it can be moved and turned in any direction, by only one or two men, even when it weighs three tons. For this purpose an iron pulley *k* is hooked to the iron loop *n* of the crane; and a short endless chain *l* passed over the pulley suspends the faggot in its loop. In this manner the weight of the iron is in reality borne by the pivot of the pulley *k*, and the mass can be easily turned round upon its centre to bring any side upwards. To give a power to the man who guides it, one of the four central bars is double the length of the faggot, and projects, see *g*, to form a long lever, by which it is steered; and two holes are made through the end of this bar to insert a cross lever *k*, by which the faggot is turned or rolled round upon its centre. As the faggot hangs very nearly on a balance in the loop of the chain *l*, the man, by weighing on the end of the long bar *g*, can easily raise up its end from the anvil K, and, swinging the crane on its pivots, move it into the fire, which is made up hollow like an oven. To effect this form, the fireman first spreads the coals evenly upon the hearth, and with his shovel or slice makes a flat surface about the level of the tue-hole: he then arranges some large cinders or cakes round in a circle upon this surface, and by other cinders builds it up like an oven or dome, leaving a mouth to introduce the iron. The oven is adapted in size to the magnitude of the mass of iron, and must be brought forwards upon the hearth, to leave a space between its interior cavity and the orifice of the tue-iron; in which space a passage is made from the tue-hole to the fire, and filled up with large lighted coals, and then covered up by small coals. The blast from the bellows passes through these hot coals, in order that the cold air may not enter the fire at once and blow on the iron, but be first converted into flame, which is urged forcibly into the oven, and reverberated from the roof and sides upon the iron placed in the centre. As the floor of the oven is nearly upon a level with the tue-hole, the flame from the coals between it and the fire also plays upon the bottom, and thus heats the iron on all sides. The outside of the dome is covered over with a considerable thickness of small coals, which cake together, and, as the inside of the oven consumes, settle down into a dome again, which the smith aids by striking the outside with the flat of his slice. If the fire breaks out at any place in the roof, the smith immediately repairs the breach with fresh coals, and damps them with water, that they may not burn too fast; for if the inside of the oven burns very fiercely, the flames will not be reverberated so forcibly as when it is in the state of burning cake. Care must likewise be taken to prevent the fire from burning back to the tue-iron. The mouth of the oven should be made no larger than to admit the work; and, that as little heat as possible may escape by the iron, the mouth is filled round it with coals. F is an iron screen hung on

Anchor. hinges, to swing before the mouth of the fire when the iron is withdrawn, that the workmen may not be scorched by the heat.

All the men unite to assist in blowing the bellows, which they work in the manner already described, from half an hour to an hour, according to the size of the anchor, until they have raised the iron to a good welding heat. The mouth of the fire is opened occasionally to inspect the process, and the faggot is turned in the fire if it is not found to be heating equally in every part. Eight men, and sometimes more, are employed to forge an anchor: six of them strike with the hammers, one is stationed at the guide-bar, and the eighth, who is master or foreman, directs the others, and occasionally assists to guide the anchor. When the whole of that part which is in the fire comes to a good welding heat, the workmen leave the bellows and take up their hammers; the coals are removed from the iron, which is swung out of the fire by the man who guides it, assisted by others, and the hot end placed on the anvil; during which time one or two labourers with birch brooms sweep off the coals which adhere to it.

The smiths now begin hammering, one half the number standing on one side, and the other half on the other: they use large sledges weighing from sixteen to eighteen pounds, and faced with steel, striking in regular order, one after the other, swinging the hammers at arms' length, and all striking nearly at the same place. The foreman places himself near the man who guides, and with a long wand points out the part he wishes them to strike, and at the same time directs and sometimes assists the guide to turn the faggot round, so as to bring that side uppermost which requires to be hammered. This is continued as long as the metal retains sufficient heat for welding. This process is exceedingly laborious for the workmen, and is much more effectually performed by means of the Hercules, which strikes such powerful blows upon the iron as to consolidate the bars much more than the strokes of small hammers can do, however long they may be continued. When the iron has lost so much of the heat that it will no longer weld, the foreman takes a number of pins, made like very thick nails without heads: one of these he holds in the end of a cleft stick, places its point upon the iron, and two smiths, with their sledges, strike on it with all their force, to drive it through the bars; but this they must do quickly, or the pins will become hot and soft, so as not to penetrate the bar. These pins are intended to hold the whole together more firmly, and, by swelling out the sides, to fill up any small spaces there may be between the bars. The iron is now returned to the fire, another mouth being opened on the opposite side of the oven, to admit the end or part which has been welded to come through, that a part farther up the faggot may be heated; and when this is done the welding is performed in the same manner as before. Thus, by repeated heatings, the faggot is made into one solid bar of the size and length intended. It is then hammered over again at welding heats to finish it, and make an even surface; and in this second operation the workmen do not leave off hammering as soon as the iron loses its full welding heat, but continue till it turns almost black. This renders the surface solid and hard, and closes all small pores at which the sea-water might enter, and by corroding the bars, expand them, and in time split open the mass of iron.

The shank for an anchor is made larger at the lower end, where the arms are to be welded to it, and is of a square figure. A sort of rebate or scarf *s* is here formed on each side of the square, in order that the arms may apply more properly for welding. This scarf is made in the original shape of the faggot, and finished by cutting away some of the metal with chisels whilst it is hot, and using sets or punches, properly formed, to make a square angle to the shoulder of the scarf. The upper end of the shank is likewise square; and the length between these square parts is worked either to an octagon or round, tapering regularly from the lower to the upper end. The hole to receive the ring of the anchor is pierced through the square part at the upper end, first by a small punch, and then larger ones are used till it is sufficiently enlarged. The punch is made of steel; and when it is observed to change colour by the heat, it is struck on the opposite end to drive it out, and is instantly dipped in water to cool it, and another driven in. The projecting pieces or nuts, which are to keep the stock or wooden beam of the anchor, and its place on the shank, are next welded on. To do this the shank is heated, and at the same time a thick bar is heated in another forge: the end of this is laid across the shank, and the men hammer it down to weld it to the shank; then the piece is cut off by the chisel, and another piece welded on the opposite side.

Whilst this process of forging the shank is going on, the smiths of another forge, placed as near as convenient to the former, are employed in making the arms, which are made from faggots in the same manner as the shank, but of less size and shorter: they are made taper (see X), one end of each being smaller than the other: the larger ends are made square, and cut down with scarfs, *r*, to correspond with those, *s*, at the lower end of the shank. The middle parts of the arms are rounded, and the outer extremities are cut away as much as the thickness of the flukes or palms *m*, that the palms may be flush with the upper sides when they are welded on. The flukes are generally made at the iron-forges in the country, by the forge-hammer; but in some yards they are made by faggoting small bars, leaving a long one for a handle. When finished, they are welded to the arms, which have then the appearance of X. The next business is to unite the arms to the end of the shank; and in doing this particular care is necessary, as the goodness of the anchor is entirely dependent upon its being effectually performed. In so large a weld, the outside is very liable to be welded, and make a good appearance, while the middle part is not united. To guard against this, both surfaces of the scarfs should be rather convex, that they may be certain to touch in the middle first. When the other arm is welded, the anchor is complete, except the ring, which is made from several small bars welded together, and drawn out into a round rod, then bent to a circle, put through the hole in the shank, and its ends welded together. If the shank or other part is crooked, it is set straight by heating it in the crooked part, and striking it over the anvil, or by the Hercules. After all this the whole is heated, but not to a white heat, and the anchor hammered in every part, to finish and make its surface even. This is done by lighter hammers, worked by both hands, but not swung over the head. This operation renders the surface of the metal hard and smooth; and if very effectually performed, the anchor will not rust materially by the action of the sea-water. The hammering is continued till the iron is quite black and almost cold. It is common with some manufacturers, after they have made up the shank, to heat it again, and apply the end of a thin flat bar properly heated upon it; then by turning the large shank round, the bar is wound spirally upon it, so as to form a complete covering to the whole. This method admits of employing a kind of iron which is less liable to corrosion, but we fear it is sometimes resorted to to conceal the bad qualities of the iron of which the anchor is composed.

The iron from which anchors are made ought to be of the best quality: that kind of it which is called red short

will not bear sufficient hammering to weld the bars; and cold short, from its brittleness, is not to be depended upon when the anchor is in use. A good anchor should be formed of the toughest iron that can be procured.

A new and improved method of fabricating anchors, for which a patent has been taken out by Lieutenant Rodgers, has been lately introduced. This consists in making the shank hollow, and uniting it to a solid square at one end, and to a solid piece at the other, which forms the crown and part of the arms. The hollow part is bound at intervals by hoops, and the whole forms a much stronger anchor, of the same weight, than those of the common construction. The stock also is let on over the end of the square, and keyed up against a collar, by which means the anchor can be unstocked with great facility. See Plate XLIII. fig. 7.

The most extensive establishment for fabricating anchors, &c. is that at Woolwich dock-yard. There the blowing apparatus, the working of the lift and tilt hammers, &c. is all done by a steam-engine of from 14 to 16 horse power. The improvements of Perring and Rodgers have been there introduced. (c.)

To steer the ship to her Anchor, is to steer the ship's head towards the place where the anchor lies when they are heaving the cable into the ship, that the cable may thereby enter the hause with less resistance, and the ship advance towards the anchor with greater facility.

Anchor-Ground is a bottom which is neither too deep, too shallow, nor rocky; as in the first the cable bears too nearly perpendicular, and is thereby apt to jerk the anchor out of the ground; in the second, the ship's bottom is apt to strike at low water, or when the sea runs high, by which she is exposed to the danger of sinking; and in the third, the anchor is liable to hood the broken and pointed ends of rocks, and tear away its flukes, whilst the cable, from the same cause, is constantly in danger of being cut through as it rubs on their edges.

Anchor, in *Architecture*, is a sort of carving somewhat resembling an anchor. It is commonly placed as part of the enrichment of the boultins of capitals of the Tuscan, Doric, and Ionic orders, and also of the boultins of bed mouldings of the Doric, Ionic, and Corinthian cornices, anchors and eggs being carved alternately through the whole building.

Anchors, in *Heraldry*, are emblems of hope, and are taken for such in a spiritual as well as a temporal sense.

ANCHOVY. See Ichthyology.

ANCIENT, or Antient, a term applied to things which existed long ago. Thus we say, ancient nations, ancient customs, &c. See Antiquities.

ANCIENT Demesne, in *English Law*, is a tenure whereby all manors belonging to the crown in the times of William the Conqueror and St Edward were held. The numbers, names, &c. were entered by the Conqueror in the record called *Domesday Book;* so that such lands as by that book appeared to have belonged to the crown at that time are called *ancient demesne.*

ANCIENTY, in some ancient statutes, is used for eldership or seniority. The elder sister can demand no more than her other sisters, beside the chief mesne, by reason of her ancienty. This word is used in the statute of Ireland, 14 Henry III.

ANCONA, a delegation or province of the Papal States, in Italy, a part of the ancient mark of Ancona. It is bounded on the north by Urbino, on the east by the Adriatic Sea, on the south by Macerata, and on the west by Urbino. Its extent is 646 square miles, or 413,440 acres. It is a mountainous district, with scarcely any plains; but between the projections of the Appenines there are some valleys, watered by the Musone, the Esino, the Aspino, and several smaller mountain rivers, which yield good crops of corn, maize, garlic, fruit, almonds, tobacco, and some silk. Agriculture is much neglected, but more attention is paid to cattle. The delegation contains 3 cities, 17 market-towns, and 34 villages; and in 1816 the number of inhabitants was 147,355, who, besides agriculture, find employment in manufactures of linen, silk, stockings, paper, and some other articles. The country is remarkably healthful.

Ancona, the capital of the delegation of the same name. The city is in lat. 43° 43′ 36″ N. and long. 12° 42′ 27″ E. It is situated on the declivity of a tongue of land projecting into the Adriatic Sea, on which, after the destruction of the fortifications in 1815, a strong fort was built as a defence towards the sea. It has three gates towards the land. The most striking objects are the government palace, the town-house, the exchange, and the cathedral built at the extremity of the cape, on the site of an ancient temple of Venus. There is a college, an hospital, and several monasteries and nunneries. The inhabitants in 1816 were 29,792, among whom were 5000 Jews, who live in a separate quarter. The streets are narrow, and far from clean. There is a fine mole 2000 feet in length, on which a lazaretto and quarantine-house is built. The harbour is capacious, but complaints are made of the mud gradually increasing and injuring it. The trade is carried on by means of about 1100 vessels, which arrive and depart annually. This place endured a long siege in the year 1799, but at length the French garrison who defended it surrendered to a combined army and navy of Russians, Austrians, and Turks.

ANCONES, in *Architecture*, the corners or quoins of walls, cross beams, or rafters. Vitruvius calls the *consoles* by the same name.

ANCOURT, Florent Carton d', an eminent French comic writer and actor, was born at Fontainbleau, on the 1st November 1661. He died on the 6th of December 1726, being 65 years of age. The plays which he wrote were all, with one exception, of the comic cast. They have been frequently reprinted, and form, in the best edition, namely, that of 1760, a collection of 12 vols. 12mo.

ANCRE, a small town of France, in Picardy, with the title of a marquisate, seated on a little river of the same name. Long. 2. 45. E. Lat. 49. 59. N.

ANCUS Martius, the fourth king of the Romans, succeeded Tullus Hostilius 639 years before Christ. He defeated the Latins, subdued the Fidenates, conquered the Sabines, Volsci, and Veientines, enlarged Rome by joining to it Mount Janiculum, and made the harbour of Ostia. He died about 615 years before the Christian era.

ANCYLE, in *Antiquity*, a kind of shield that fell, as was pretended, from heaven, in the reign of Numa Pompilius; at which time, likewise, a voice was heard declaring that Rome should be mistress of the world as long as she should preserve this holy buckler. It was kept with great care in the temple of Mars, under the direction of 12 priests; and, lest any should attempt to steal it, 11 others were made so like as not to be distinguished from the sacred one. These ancylia were carried in procession every year round the city of Rome.

ANCYLOBLEPHARON (from αγκυλος, *bent*, and βλεφαρον, *an eyelid*), a disease of the eye, which closes the eyelids.

ANCYLOGLOSSUM (from αγκυλος, *crooked*, and γλωσσα, *the tongue*), a contraction of the ligaments of the tongue. Some have this imperfection from their birth, others from some disease. In the first case, the membrane which supports the tongue is too short or too hard; in the latter, an ulcer under the tongue, healing and forming a cicatrix, is sometimes the case. These speak with some difficulty. The ancyloglossi by nature are late before

they speak; but when they begin, they soon speak properly. These we call *tongue-tied.*

ANCYLOSIS, in *Surgery*, implies immobility or stiffness of the joints, and is used to express such stiffness, whether proceeding from internal or external causes.

ANDABATÆ, in *Antiquity*, a sort of gladiators, who, mounted on horseback or in chariots, fought hoodwinked, having a helmet that covered their eyes.

ANDALUSIA, an extensive province in the south of Spain, on the Mediterranean Sea. Though its surface is very unequal, and its soil and climate vary with the elevations of the land, it must be considered the most rich and delightful of all the divisions of the peninsula. It is divided into four districts, which, in conformity with ancient usage, are denominated kingdoms, viz. Jaen, Cordova, Seville, and Granada, the description of each of which will be found in their alphabetical place.

ANDALUSIA, *New*, a division of the province of Terra Firma in South America, whose boundaries cannot be well ascertained, as the Spaniards pretend a right to countries in which they have never established any settlements. According to the most reasonable limits, it extends in length 500 miles from north to south, and about 270 in breadth from east to west. The interior country is woody and mountainous, variegated with fine valleys that yield corn and pasturage. The produce of the country consists chiefly in dyeing-drugs, gums, medicinal roots, brazil wood, sugar, tobacco, and some valuable timber. To this province also belonged five valuable pearl fisheries. The capital of New Andalusia is Comana, Cumana, or New Corduba, situated in lat. 10° 5′ N. about nine miles from the North Sea. Here the Spaniards laid the foundation of a town in the year 1520. The place is strong by nature, and fortified by a castle capable of making a vigorous defence. The country is better known under the name of Guiana. The revolution which began there in 1810 is not yet terminated.

ANDAMAN ISLANDS. These islands, which are situated on the eastern side of the Bay of Bengal, are a continuation of the archipelago which extends from Cape Negrais to Atchein Head, stretching from lat. 10° 32′ to 13° 40′ N., and from long. 90° 6′ to 92° 59′ E. They are called the Great and the Little Andaman. The Great Andaman, which is the northern island, is 140 miles in length, and only 20 broad. It was formerly supposed to be one island; but two straits have been discovered, which open a clear passage into the Bay of Bengal, and divide the Great Andaman into three islands. The Little Andaman, which lies 30 miles south of the Great Andaman, is 28 miles long and 17 broad. It does not afford any good harbour, though tolerably safe anchorage may be found near its shores. These islands have an extremely moist temperature. They are situated in the direct current of the south-west monsoon; and the central mountains, some of the lofty peaks of which, as Saddle Peak in the large Andaman, rise to the height of 2400 feet, intercept the clouds, which, for about eight months in the year, descend in incessant torrents of rain on the plains below. According to a meteorological table kept by an officer resident on the island, 98 inches of water appear to have fallen in the course of seven months. On the whole, however, the temperature is milder than in Bengal, and the heats not so intolerable.

The island is totally uncultivated, and the savage inhabitants glean a miserable subsistence from the spontaneous produce of the woods, in which the researches of the Europeans have hitherto found little that is either palatable or nutritious. The principal trees are the banyan-tree, the almond-tree, the oil-tree, which grows to a great height and yields a very useful oil; the poon, the dammer, the red wood, which for furniture is little inferior to fine mahogany; the ebony, the cotton-tree, the soondry, chingry, and beady; the Alexandrian laurel, the poplar, a tree resembling satin-wood, bamboos, cutch, the melon, aloes; the iron-tree, of stupendous size, whose timber almost bids defiance to the axe of the wood-cutter. There are many other trees well adapted for the construction of ships; and, as in all the equatorial forests, there are numberless creepers and ratans, which surround the stems of the trees, and are so firmly interlaced together, that the forests are impervious, except a road be previously cut through them.

The only quadrupeds seen on the island are hogs, rats, and the ichneumon; also the guana, of the lizard tribe; all which are very destructive to poultry. There are several species of snakes and scorpions, by which the labourers employed by the British in clearing away the underwood were frequently bitten; but in no instance did the bite prove mortal. The patient was frequently affected with violent convulsions, which gradually yielded to the operation of opium and eau-de-luce.

Fish abound on the shores, and are caught in great numbers during the prevalence of the north-east monsoon, when the weather is mild: grey mullet, rock cod, skate, and soles, are among the best. There are, besides, various other species, such as guanas, sardinas, roe-balls, sable, shad, prawns, shrimps, cray-fish, a species of whale, and sharks of an enormous size. Shell-fish are in great plenty, and oysters of an excellent quality. The shores abound in a variety of beautiful shells, such as gorgonias, madreporas, murex, and cowries, with many other sorts equally beautiful.

Birds are not numerous, and they are extremely shy. Doves, parroquets, and the Indian crow, are the most common. Hawks from the neighbouring continent are sometimes seen hovering over the tops of trees; and a few aquatic birds, such as the king-fisher, a sort of curlew, and the small sea-gull, frequent the shores. Within the caverns and recesses of the rocks are found the edible birds' nests so highly prized among the Chinese for their supposed medicinal and restorative qualities.

The whole population of the islands does not exceed 2000 or 2500, and they are probably the most savage people on the face of the whole earth. They are far below the ordinary scale of barbarism; and in their modes of subsistence, and in their dwellings, they rise very little above the brute creation. They wear no clothes, and seem insensible to any feeling of shame from the exposure of their persons. The woods supply them with little in the way of food. They are provided with no pot or vessel that can bear the action of fire, and they cannot therefore derive much advantage from such esculent herbs as the forests may contain. The cocoa nut, which thrives so well in the neighbouring islands, is not found in the Andamans, though the natives are extremely fond of it. The fruit of the mangrove is principally used by them. Their principal food consists of fish, in quest of a precarious meal of which they climb over the rocks, or rove along the margin of the sea, often without success during the tempestuous season; but they eagerly seize on whatever else presents itself, such as lizards, guanas, rats, and snakes. From their diseased and extenuated figures, it is plain that they have no abundant or wholesome nourishment. In stature the inhabitants of the Great Andaman seldom exceed five feet; their limbs are disproportionably slender, their bellies protuberant, with high shoulders and large heads; and, what is singular and unaccountable, they have all the characteristic marks of a degenerate race of negroes, with woolly hair, flat noses, and thick lips; their eyes are small and red, their skin of a deep sooty black, while their countenances exhibit a mixed expres-

sion of famine and ferocity. Lieutenant Alexander describes the inhabitants of Little Andaman as far from being a puny race. When he landed in a boat he counted sixteen strong and able-bodied men, many of them very lusty. The ingenuity of these savages is principally seen in the fabrication of a few simple weapons on which they depend for their subsistence. These are a bow from four to five feet long, with arrows of reed, headed with fish-bone or wood hardened in the fire, a spear of heavy wood sharply pointed, and a shield made of bark. With these implements they shoot and spear the fish, which abound in their bays and creeks, with surprising dexterity. Their habitations display little more art than the dens of wild beasts. Their canoes are hollowed out of the trunks of trees by fire and instruments of stone, as they have no iron among them. Being much incommoded by insects, their first occupation in the morning is to plaster their bodies all over with mud, which, hardening in the sun, forms an effectual defence. They paint their woolly heads with a mixture of ochre and water; and, when completely dressed, it is observed by Mr Symes, who visited the island in his voyage to Ava, that a more hideous appearance is not to be found in human form. Their language does not possess the slightest affinity to any spoken either on the continent of India or on the islands. It is not harsh to the ear. Their songs are wildly melodious, and their gesticulations when singing extremely impassioned. The men have all the cunning and vindictive dispositions of savages; and they show a marked hatred to all strangers. They have little idea of a future state, but they adore the sun and the moon, and the genii of the woods, waters, and mountains as inferior agents. During the south-west monsoon, when tempests prevail with unusual violence, they deprecate the wrath of the malignant being who, according to their notions, has occasioned the storm, by chanting wild choruses in small congregations assembled on the beach or on some rock that overhangs the ocean. These islanders have occasionally been persuaded to come on board British ships; but though they were well fed and kindly treated, no persuasion could induce them to remain. The settlement of these islands, with their negro inhabitants, so widely different in their appearance not only from all those of the Asiatic continent, in which the Andamans are embayed, but also from the natives of the Nicobar islands, presents a curious problem, which has never been satisfactorily explained. It is supposed, however, by Symes, that the original stock must have been settled on the island by the accidental shipwreck of some Arab slave-ship. The English made a settlement on the larger Andaman in the year 1791. Their object was to procure a commodious harbour on the east side of the Bay of Bengal, to receive and shelter ships of war during the continuance of the north-east monsoon; also to provide a place of reception for convicts sentenced to transportation from Bengal. But the settlement, proving unhealthy, has been since abandoned. These islands have been frequently visited by British ships, but the barbarous natives reject all friendly intercourse. Lieutenant Alexander states that they presented a hostile aspect to the party who landed in search of fresh water, assailed them with volleys of arrows, and testified, by the most ferocious signs, their determined aversion to them. In April 1824 the British armament destined against the Burmese touched at the great island, when the natives persevered in their hostility, discharging flights of arrows at their boats, and then flying into the woods. These islands, together with the Nicobar and other smaller islands, were included by Ptolemy in the general appellation of *Insulæ Bonæ Fortunæ*, and were supposed by him to be inhabited by a race of anthropophagi, though there are no proofs of the modern inhabitants being addicted to this practice. (Symes' *Embassy to Ava*; Alexander's *Travels from India to England, comprehending a Visit to the Burman Empire*, &c.; Hamilton's *Gazetteer*.) (F.)

ANDANTE, in *Music*, signifies a movement moderately slow, between *largo* and *allegro*.

ANDEGAVI, or Andegavus, a town of Gallia Celtica (Pliny, Ptolemy); now Angiers: called *Andecavi* (Tacitus). Long. 30. W. Lat. 47. 30. N.

ANDELYS, an arrondissement in the department of the Lower Seine, in France. It extends over 390 square miles, or 256,440 acres; is divided into six cantons, which are subdivided into 147 communes; and contains 63,211 inhabitants. The chief place, of the same name, has a population of 5256 souls.

ANDENA, in old writings, denotes the swath made in the mowing of hay, or as much ground as a man could stride over at once.

ANDEOL, Saint, a town of France, in the department of Lozere, five miles south of St Viviers, whose bishop formerly resided there. Long. 2. 50. E. Lat. 44. 24. N.

ANDERAB, the most southern city of the province of Balk, possessed by the Usbec Tartars. The neighbouring mountains yield excellent quarries of lapis lazuli, in which the Bukhars drive a great trade with Persia and India.

ANDERAVIA, or Inderabia, a low, level, and narrow island on the Arabian shore of the Persian Gulf, about three miles in length. It is separated from the mainland by a strait three miles in length, and free from danger; but ships running for shelter under this island must not come within a mile of its south end, until a remarkable tree, which will be distinguished standing by itself, bear west-north-west. Lat. 26. 40. N.

ANDERNACHT, a city in the duchy of the Lower Rhine, belonging to Prussia. It is situated in a plain on the river Rhine, and is fortified with a wall, castle, and bulwarks. It has a trade in stone jugs and pitchers, which are sent to the mineral waters at Dunchstein. There are three monasteries here, and several churches. Long. 7. 4. E. Lat. 50. 27. N.

ANDERO, Saint, a seaport town in the Bay of Biscay, in Old Castile, seated on a small peninsula. It is a trading town, and contains about 700 houses, two parish churches, and four monasteries. Here the Spaniards build and lay up some of their men of war. Long. 3. 45. W. Lat. 43. 20. N.

ANDERSON, Alexander, a very eminent mathematician, who flourished in the early part of the 17th century. He was born at Aberdeen, but passed over to the Continent, and settled as a private teacher or professor of mathematics at Paris, where he published or edited, between the years 1612 and 1619, various geometrical and algebraical tracts, which are conspicuous for their ingenuity and elegance. It is doubtful whether he was ever acquainted with the famous Vieta, master of requests at Paris, who died in 1603; but his pure taste and skill in mathematical investigation had pointed him out to the executors of that illustrious man, who had found leisure, in the intervals of a laborious profession, to cultivate and extend the ancient geometry, and, by adopting a system of general symbols, to lay the foundation and begin the superstructure of algebraical science, as the person most proper for revising and publishing his valuable manuscripts. Anderson did not come forward, however, as a mere editor; he enriched the texts with learned comments, and gave neat demonstrations of those propositions which had been left imperfect. He afterwards produced a specimen of the application of geometrical analysis, which is distinguished by its clearness and classic elegance.

Of this able geometer we are ignorant both of the time of his birth and of his death. His brother David Ander-

Anderson. son, a small proprietor in Aberdeenshire, but engaged in business, had likewise a strong turn for mathematics and mechanics, which, joined to great versatility of talent, made him be regarded by his neighbours at that period as a sort of oracle. The daughter of this clever and active burgess was married to John Gregory, minister of Drumoak, in that county, father to the celebrated James Gregory, inventor of the reflecting telescope; and is supposed to have communicated to her children that taste for mathematical learning which afterwards shone forth so remarkably in the family of the Gregorys.

The works of Anderson amount to six thin quarto volumes, which are now very scarce. These are,

1. Supplementum Apollonii Redivivi; sive, Analysis problematis hactenus desiderati ad Apollonii Pergæi doctrinam περι νευσεων, a Marino Ghetaldo Patritio Ragusino hucusque non ita pridem restitutam. In qua exhibetur Mechanice æqualitatum tertii gradus sive solidarum, in quibus magnitudo omnino data æquatur homogeneæ sub altero tantum coefficiente ignoto. Huic subnexa est variorum problematum practice, eodem Auctore. Parisiis, 1612, 4to. This tract refers to the problem of *inclinations*, by which, in certain cases, the application of the curve called the *conchoid* is superseded.
2. Αιτιολογια: Pro Zetetico Apolloniani problematis a se jam pridem edito in supplemento Apollonii Redivivi. Ad clarissimum et ornatissimum virum Marinum Ghetaldum Patritium Ragusinum. In qua ad ea quæ obiter inibi perstrinxit Ghetaldus respondetur, et analytices usus clarius detegitur. Parisiis, 1615, 4to. This is an addition to the author's former work.
3. Francisci Vietæ Fontenacensis de Æquationum Recognitione et Emendatione Tractatus Duo. Parisiis, 1615, 4to. To this work Anderson has supplied the dedication, preface, and appendix.
4. Ad Angularium Sectionum Analyticen Theoremata Καθολικωτερα, a Francisco Vieta Fontenacensi excogitata, at absque ulla demonstratione ad nos transmissa, jam tandem demonstrationibus confirmata. Parisiis, 1615, 4to.
5. Vindiciæ Archimedis; sive, Elenchus Cyclometriæ Novæ a Philippo Lansbergio nuper editæ. Parisiis, 1616, 4to.
6. Alexandri Andersoni Scoti Exercitationum Mathematicarum Decas prima; continens Quæstionum aliquot, quæ nobilissimorum tum hujus tum veteris ævi Mathematicorum ingenia exercuere, Enodationem. Parisiis, 1619, 4to. (B.)

Anderson, *Sir Edmund*, a younger son of an ancient Scotish family settled in Lincolnshire. He was some time a student of Lincoln College, Oxford, and removed from thence to the Inner Temple, where he applied himself diligently to the study of the law, and became a barrister. In 1582 he was made lord chief justice of the common pleas, and in the year following was knighted. He held his office to the end of his life in 1605. His works are, 1. Reports of many principal Cases argued and adjudged in the time of Queen Elizabeth in the Common Bench, Lond. 1644, fol.; 2. Resolutions and Judgments on the cases and matter agitated in all courts of Westminster in the latter end of the reign of Queen Elizabeth, Lond. 1655, 4to.

Anderson, *James, LL.D.* The subject of this article, who has been brought into notice principally from the more recent encouragement given to agriculture, and the versatility of his own genius, was born at the village of Hermiston, in the county of Edinburgh, in the year 1739. His parents were in humble life, and had possessed a farm for some generations, which he was destined to inherit and to cultivate. At that period improvement was in infancy, and the husbandman had to contend with a climate whose uncertainty seemed to keep pace with the progress of his skill, and which too often disappointed him of the fruits of his industry. Anderson, while yet at an early age, lost his parents: however, his education was uninterrupted; and conceiving that an acquaintance with chemistry would promote his profession, he attended a course of lectures on that science, then delivered by Dr Cullen. None of the other pupils besides himself took notes of his lectures, which being afterwards surreptitiously obtained from him, with the design of publication, he defeated the intended purpose, apprehensive that his preceptor's fame might be diminished by these imperfect transcripts. His own active occupations had already commenced, and, along with the practice of husbandry, he prosecuted his original taste for literature.

Enlarging the sphere of his employments, Anderson forsook his first possession, for a farm of 1300 acres, which he rented in Aberdeenshire, though nearly in a state of nature, and where agriculture is still behind the southern districts. But previous to this he became known to men of letters, by some essays on planting, which, under the signature Agricola, he ventured to commit to the world through the medium of the *Edinburgh Weekly Magazine*, in 1771. Soon embarking in a higher sphere of literature, he composed the article *Monsoon* for the first edition of this Encyclopædia, in 1773, wherein he threw out some luminous ideas, and, among other observations, predicted from physical facts, and the state of geographical knowledge, that no polar continent would be found by the circumnavigators then employed by government. In the year 1777 he published a considerable quarto volume, said to have been composed two years preceding, on the means of exerting a spirit of national industry with regard to agriculture, commerce, manufactures, and fisheries; and in this he enters into detailed views of many subjects of political economy. The interest of the Highlands and Islands of Scotland is in a particular manner considered; and the author maintains, that the only effectual means of increasing agriculture is by promoting manufactures; as also, that the neglect which the agriculture of these parts of the kingdom experienced, resulted from the neglect of manufactures. Scotland, he affirms, is better adapted than England for the production of wool; and this, as well as other products, he thought, would be best encouraged by premiums. The advantages which might result from attending to the fisheries, he judged, would be very great, and the shoals of herrings frequenting the coast could be converted into a source of national wealth under suitable establishments. Anderson, who soon after had the degree of doctor of laws conferred on him by the University of Aberdeen, did not abandon these inquiries. He printed a tract regarding the fisheries, which was circulated among his friends; and, in consequence of being more widely diffused, he was appointed by the Lords of the Treasury to survey the western coast of Scotland, for the purpose of obtaining satisfactory information on the subject. This he did in 1784, and received the full approbation of his employers; and he published a brief account of the Hebrides, a chain of islands then as little within the general acquaintance of the inhabitants of Great Britain as if they had been under the dominion of another country. The principal obstacles to the fishery, Dr Anderson considered, were to be found in a duty on salt and coals, and he recommended the repeal of both. It is certain that, from thenceforward, this great branch of national industry has received infinitely more patronage than before his report, and, while we only shared the labours of the Dutch for centuries, the fisheries on our own coast have since been monopolized by ourselves. No-

nothing can be more impolitic than to fetter the exertions of the industrious by exorbitant duties, or equally oppressive with denying fuel to the poorer classes, where it is scarce, by duties on its importation.

Dr Anderson had now withdrawn from his northern farm, where he resided above 20 years, and settled in the vicinity of Edinburgh. His agricultural speculations were still continued; and when a parliamentary grant was about to be proposed to Mr Elkington for a particular mode of draining land, he reclaimed the practice as having been observed by himself many years anterior. Repeated examples, indeed, prove that the rewards granted by Parliament for improvement are attended with such slight investigations, that the merits of real invention are overlooked. Dr Anderson now projected a periodical publication called *The Bee*, consisting of miscellaneous original matter, which attained the extent of 18 volumes in octavo. It was published weekly, and a large proportion of it came from his own pen, which is seldom a prudent course in an editor. The relation of Great Britain and her colonies, and the political rights of mankind—subjects which had excited strong interests throughout Europe—also received some commentaries from Dr Anderson. He wrote a tract called *The Interest of Great Britain with respect to her Colonies*, and commenced a correspondence with General Washington, which was afterwards published.

Towards the year 1797 he again removed to Islesworth, in the neighbourhood of London, where he undertook another periodical publication, appearing at more distant intervals than the former, entitled *Recreations in Agriculture, Natural History, Arts, and Miscellaneous Literature.* This work was prefaced by two copious dissertations, the one on agriculture, the other on natural history; and opened with a discussion regarding a very curious and important subject, namely, an inquiry into what are denominated varieties in plants and animals. Many useful and interesting remarks appear in the course of this publication, a portion of which was supplied by other contributors; and it is embellished by beautiful vignettes from engravings on wood. Owing to some difficulties attending the publication, it ceased in 1802. Though natural history is rather predominant, the rest of his leading subjects are not overlooked. Dr Anderson henceforward lived in a great measure in retirement, though occasionally reminding the world of his wonted inquiries, by the publication of tracts on unconnected subjects. He obtained a patent for an improved hot-house, wherein no fuel was used; and employed himself in experiments regarding the degree of temperature and humidity most beneficial to plants. Likewise, having observed the uncommon depredations of wasps, he is said, after satisfying himself of their manner of increase, to have devised a plan for their absolute extermination. This was chiefly by the destruction of the females before founding their respective colonies by the depositation of innumerable eggs; and hand-bills were circulated under the auspices of an association formed by him, offering a reward for every female brought in dead within a specified time. It does not appear, however, that the breed was at all diminished by the proposed expedient.

Dr Anderson still remained in his retreat, enjoying the cultivation of his garden; and nothing of importance is known to have proceeded from his pen. After a gradual decline, partly occasioned by the over-exertion of the mental energies, he died in the year 1808, aged 69. He was twice married; first, to Miss Seton of Mounie; secondly, to an English lady. By his first marriage he had thirteen children, six of whom survived him. One of his sons made distinguished progress in the art of engraving on wood; and, if the vignettes of the *Recreations in Agriculture* were executed by him, they afford ample testimony of his abilities.

Dr Anderson was endowed with a vigorous understanding, which he chiefly displayed in treating of agricultural matters, and those connected with rural economy; but he was at the same time of a versatile talent, which could readily be occupied on transient facts and occurrences. Many of his works were of a fugitive nature, consisting of small impressions, which were not renewed, and hence are difficult to be obtained at present, if they have not totally disappeared. None of them soars to the more lofty regions of science; they are directed to practical views in useful projects, and for the most part relate to subjects of ordinary detail. Of this the reader will be enabled to judge by the subjoined list, which we believe is the most copious that has yet appeared. The industry of Dr Anderson was indefatigable, whether in personal exertion or mental energy; and he possessed elevated sentiments of independence. During a period of overstrained political fervour, certain papers formed part of the periodical works already referred to, which were thought libellous on the government. Although Dr Anderson's principles were noted for attachment to the existing administration, he was called upon to give up the author of the obnoxious compositions, which he steadily refused, and, even in the face of the civil magistrates, charged his printers not to violate their fidelity to him and the author in betraying his name. The business terminated here, until a factious individual insinuated to the same magistrates that the compositions had proceeded from one of the supreme judges, whose party politics were avowedly hostile to those of government. Dr Anderson having learned the reproach, hastened to relieve the object of it by divulging the name of the real author, who, to the universal surprise of the public, proved to be none other than the traducer himself.

1776. A Practical Treatise on Chimneys, containing full instructions for constructing them in all cases, so as to draw well, and for removing smoke, 12mo.
1776. Free Thoughts on the American Contest, 8vo.
1777. Observations on the Means of exciting a Spirit of National Industry, 4to.
1777. Miscellaneous Observations on Planting and Training Timber Trees, by Agricola, in 8vo.
1777. An Inquiry into the Nature of the Corn Laws, in 8vo.
1777. Essays Relating to Agriculture and Rural Affairs, 8vo. A fifth edition, in 3 volumes, was published in 1800.
1779. An Inquiry into the Causes that have hitherto retarded the Advancement of Agriculture in Europe, 4to.
1782. The Interest of Great Britain with regard to her American Colonies considered, 8vo.
1783. The True Interest of Great Britain considered, or a Proposal for Establishing the Northern British Fisheries, 12mo.
1785. An Account of the Present State of the Hebrides and Western Coast of Scotland, being the Substance of a Report to the Lords of the Treasury, 8vo.
1789. Observations on Slavery, particularly with a View to its Effects on the British Colonies in the West Indies, 4to.
1790. Papers by Dr Anderson and Sir John Sinclair on Shetland Wool, 8vo.
1791. The Bee, 18 vols. 8vo.
1792. Observations on the Effects of the Coal Duty, 8vo.
1793. Thoughts on the Privileges and Powers of Juries, with observations on the State of the Country with regard to Credit, 8vo.

Anderson.

1793. Remarks on the Poor's Laws of Scotland, 4to.
1794. A Practical Treatise on Peat Moss, 8vo.
1794. A General View of the Agriculture and Rural Economy of the County of Aberdeen, and the Means of its Improvement, 8vo.
1794. An Account of the Different Kinds of Sheep found in the Russian Dominions, by Dr Pallas. With five Appendixes, by Dr Anderson. 8vo.
1795. Two Letters, to Dr Edward Home, on an Universal Character, in 8vo.
1797. A Practical Treatise on Draining Bogs and Swampy Grounds, with Cursory Remarks on the Originality of Elkington's Mode of Draining Lands, 8vo.
1799. Recreations in Agriculture, 6 vols. 8vo.
1800. Selections from Correspondence with General Washington, 8vo.
1801. A Calm Investigation of the Circumstances that have led to the Present Scarcity of Grain in Great Britain; suggesting the means of alleviating that evil, and of preventing the occurrence of such a calamity in future; 8vo.
1803. Description of a Patent Hot-house, which operates chiefly by the Heat of the Sun, and other Subjects, 8vo.

Dr Anderson, besides, wrote many papers in periodical publications, and an account of Ancient Fortifications in the Highlands, read to the Society of Scotish Antiquaries.

Anderson, *Robert*, the fourth son of William Anderson, and of Margaret Melrose his wife, was born at Carnwath in Lanarkshire on the 7th of January 1750. His father was a *feuar*, that is, a person who possessed some small parcels of real property by the tenure of a perpetual lease. Having received the earlier part of his education in his native town and in the adjacent village of Libberton, he was afterwards placed under the tuition of Robert Thomson, master of Lanark school, who had married a sister of Thomson the poet, and who has been commended for his uncommon proficiency in classical learning. Excellence however is always a relative term; nor must it be forgotten that the grammar schools of Scotland had about that period descended to their very lowest level. James Græme, a native of the same town, was his companion and friend at all these seminaries: he appears to have been an amiable young man of promising talents, and to have been imbued with the love of literature. One of their school-fellows at Lanark was John Pinkerton, who afterwards became a conspicuous member of the republic of letters.

Anderson's father had died in 1759, in the 40th year of his age, leaving his widow with a very slender provision. Uniting considerable energy of character with a large share of piety, she made a vigorous effort to educate her four sons; and as she survived till the year 1796, she had the satisfaction of seeing one of them arrive at independence and distinction. Having discovered an early taste for reading, he soon made choice of one of the liberal professions. His first destination was for the church: in the year 1767 he was sent to the university of Edinburgh, and in due time was enrolled among the students of divinity. Græme, who had entered the university at the same time and with the same views, died of consumption in 1772, in the 23d year of his age; and, after a short interval, his faithful friend published a collection of *Poems on several occasions, by James Græme.* Edinb. 1773, 12mo. These poems he inserted in the 11th volume of the *British Poets*, together with an account of the author, in which his literary merits are estimated, not with the discrimination of sober criticism, but with all the partiality of friendly zeal. About this period he relinquished the study of divinity, and betook himself to the study of medicine. He was for a short time employed as surgeon to the dispensary at Bamborough Castle in Northumberland; and in a neighbouring town he then formed connections which had no small influence on his future destiny. On the 25th of September 1777 he married Anne, the daughter of John Grey, Esq. of Alnwick, who was related to the noble family of that name. Returning to Scotland, he took the degree of M. D. at St Andrews on the 20th of May 1778, after having been duly examined by the professor of physic. He now began to practise as a physician at Alnwick; but his general habits were rather those of speculation than exertion, and a moderate provision, acquired by his marriage, had emancipated him from the necessity of professional labour. In 1784 he finally returned to Edinburgh, where he continued to reside for the period of 46 years, in a condition of life removed from affluence, but perfectly compatible with genuine independence and comfort. He possessed the valuable secret of living within his income; and his house was long distinguished by a hearty and unostentatious hospitality. His amiable and affectionate wife died of consumption on the 25th of December 1785, in the 39th year of her age, leaving three daughters, the youngest of whom speedily followed her mother to the grave. He did not resume the practice of physic, but being satisfied with his moderate acquisitions, he devoted much of his time to the education of his two children, and to miscellaneous and desultory reading, rather than to any systematical course of study. In 1793, after having remained a widower for eight years, he married Margaret, the daughter of Mr David Dall, master of Yester school in the county of Haddington.

For several years his attention was occupied with his edition of *The Works of the British Poets, with Prefaces biographical and critical*, which was published at Edinburgh, and extends to 14 large octavo volumes. The earliest volume, which is now the second in the series, was printed in 1792–3; the 13th was printed in 1795, and another volume was added in 1807. He was frequently solicited to revise his Lives of the Poets, and publish them in a separate form; but after having collected some materials for such a work, he finally abandoned the design. In the mean time he had published *The Miscellaneous Works of Tobias Smollett, M. D. with Memoirs of his Life and Writings.* Edinb. 1796, 6 vols. 8vo. The sixth edition of this collection was printed in the year 1820. Of his account of the ingenious author, the eighth separate edition appeared under the title of *The Life of Tobias Smollett, M. D. with critical Observations on his Works.* Edinb. 1818, 8vo. But the most able and elaborate of his productions is the third edition of his *Life of Samuel Johnson, LL. D. with critical Observations on his Works.* Edinb. 1815, 8vo. The same service which he rendered to Dr Smollett he afterwards extended to Dr Moore, having published *The Works of John Moore, M. D. with Memoirs of his Life and Writings.* Edinb. 1820, 7 vols. 8vo. At an earlier period he had published *The Poetical Works of Robert Blair; containing the Grave, and a Poem to the Memory of Mr Law: to which is prefixed the Life of the Author.* Lond. 1794, 8vo. And his latest publication was *The Grave, and other Poems, by Robert Blair: to which are prefixed, some Account of his Life, and Observations on his Writings.* Edinb. 1826, 12mo.

Dr Anderson contributed his ready aid to many different publications, and was always influenced, not by the love of money, but by the love of literature. With many eminent men in England, Ireland, and America, he maintained a literary correspondence; and having survived most of his lettered contemporaries, he enjoyed the

esteem and consideration of a second and even of a third generation. In 1802, 1809, and 1810, he paid three long visits to Dr Percy, the late excellent Bishop of Dromore; and he likewise enjoyed the friendship of Dr Ledwich, Dr Ryan, Mr Boyd, Mr Cooper Walker, and many other literary men of the sister island. No part of his character was more conspicuous than his uniform and unabating zeal to promote the success of young men who discovered any promise, however moderate, of literary talent; and some of the more distinguished writers of our own age and nation were not without their obligations to his disinterested friendship. Mr Campbell dedicated to him his earliest and most popular publication, *The Pleasures of Hope*. Miss Bannerman, a very ingenious and accomplished lady, who died at Portobello on the 29th of September 1829, dedicated to him her first collection of *Poems*. Edinb. 1800, 8vo. Thomas Brown, John Leyden, and Alexander Murray, who all died at too early an age, were among the most eminent of his young friends. For Dr Brown, who became professor of moral philosophy in the university of Edinburgh, he entertained a very cordial esteem, which suffered no abatement or interruption. Another prominent feature of his mind, was his ardent regard for the civil and religious liberties of mankind. This characteristic he displayed from the first years of manhood till the last day of his earthly existence; and, on the very evening before his death, he gave a signal proof of his unquenchable zeal, by sending for a map of Greece, in order, as he expressed himself, to form some notion of the general elements of this new state. His principles were those of a very decided Whig; and, during the extraordinary excitement which attended the close of the last century, he was sometimes misrepresented as little better than a republican. The honest alarm of one class of individuals, and the hollow zeal of another, had a strong tendency to confound all nice distinctions.

His bodily frame had never been robust; but the uniform temperance and regularity of his habits contributed to prolong a life which was marked by cheerfulness and benevolence. His faculties, mental and corporeal, betrayed few or no symptoms of old age. During the greater part of his last winter he was confined to his own house by what was considered as a common cold, and was attended by his friend and contemporary Dr Hamilton. His lungs however seemed to be affected in an unusual manner; and, five days before his dissolution, his physician discovered that dropsy in the chest had supervened. As he had now reached a very advanced age, he indulged not even the faintest hope of recovery. Though his chief or only suffering proceeded from difficulty of respiration, the progress of his malady was swift and certain: but the native alacrity of his mind seemed incapable of diminution; and maintaining much and varied conversation during the last days, and indeed during the last hours of his life, he evinced more than his usual continuity of thought and accuracy of expression. As the vital tide was rapidly receding, his heart seemed to expand with new kindness towards all those who approached his couch. Of the immediate prospect of death he spoke, not merely with resignation, but even with cheerfulness; with the subdued but confident hope of one who had long and habitually reposed on the assurances of the Christian faith. He died on Saturday the 20th of February 1830, after having completed the 80th year of his age; and, according to his own directions, his remains were interred in Carnwath churchyard. His eldest daughter, Anne Margaret, was married in 1810 to David Irving, LL. D. and died in 1812, leaving an only son. His second daughter, Margaret Susannah, lived to deplore the loss of a parent, whose declining years she had soothed by the most exemplary attention to all his wants and wishes. (x.)

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ANDES. The Andes are distinguished above all the known mountain chains by their immense extent and their prodigious altitude. They run almost parallel to the west coast of the southern continent of America, at a mean distance of between 100 and 200 miles, rising in some places to the enormous height of 25,000 feet; and stretch from the mouth of the river Atrato, on the isthmus of Darien, in the latitude of 8 degrees north, as far as Cape Pilares, at the outlet of the Straits of Magellan, in the 53d degree of south latitude, a range of at least 4200 miles. They send out, nearly at right angles from their colossal ridge, between the latitudes of 14° and 20° south, three dependent branches, called by the Spaniards *Cordilleras*.

Of these secondary chains, the *first* and most northern is that of the coast of Venezuela, which is likewise the highest and narrowest. With an irregular altitude, it bends eastwards from the Atrato, forming the Sierra of Abibé, the mountains of Cauca, and the high Savannahs of Folu, till it reaches the stream of Magdalena, in the province of St Martha. It contracts as it approaches the Gulf of Mexico, at Cape Vela; and thence extends to the mountain of Paria, or rather the Galley Point, in the island of Trinidad, where it terminates. This secondary chain attains its greatest known elevation where it rears the snowy summit, or Sierra Nevada, of St Martha and of Merida, the former being nearly 14,000 and the latter above 15,000 feet in altitude. These insulated mountains, covered so near the equator with eternal snow, yet discharging boiling sulphurous water from their sides, are higher than the Peak of Teneriffe, and can be compared only with Mont Blanc. In their descent they leave the Paramo or lofty desert of Rosa and of Mucachi; and on the west side of the lake Maracaibo they form long and very narrow vales, running from south to north, and covered with forests. At Cape Vela the mountain chain divides into two parallel ridges, which form three confined valleys ranging from east to west, and having all the appearance of being the beds of ancient lakes. These ridges, of which the northern is the continuation of the Sierra Nevada of St Martha, and the southern the extension of the snowy summits of Merida, are united again by two arms which seem to have been placed by the hand of nature as dikes to confine the primeval collections of water. The three valleys thus inclosed are remarkable for their elevation above the sea, rising like steps one above another, the eastmost, or that of the Caraccas, being the highest. This plain was found by Humboldt to be elevated 2660 feet, while the basin of Aragua has only 1350 feet in height, and the Llanos, or reedy plains of Monai, spread within 500 or 600 feet above the level of the shore. The lake of the Caraccas appears to have forced a passage for itself through the *quebrada* or cleft of Tipé, while that of Aragua has been gradually dissipated by a slow process of evaporation, leaving some vestiges of its former existence in pools charged with muriate of lime, and in the low islets called *Aparecidas*. The medium height of the Cordillera of the coast is about 4000 or 5000 feet; but its loftiest summit, next to the Sierra Nevada of Merida, is the *Silla* (or saddle) of the Caraccas, which was visited by Humboldt, and ascertained from barometrical measurement to have an elevation of 8420 feet. Farther to the eastward the mountain chain becomes suddenly depressed, especially its primitive rocks; the beds of gneiss and mica slate meeting as they advance with accumulations of secondary calcareous substances, which envelope them completely, and rise to a great elevation. The incumbent mass of sandstone, with a calcareous base, extending from

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Capelluari, forms a detached range of mountains, in which no trace of primitive rock is found.

The *second* branch, which stretches from the Andes across the American continent, and exhibits a chain of primitive mountains, is named by Humboldt the *Cordillera of the Cataracts of Orinoco.* This very enterprising traveller surveyed it over an extent of upwards of 600 miles, from the Black River to the frontiers of the Great Bara; but the rest of the chain is very little known, running through unexplored wilds and regions almost inaccessible, occupied by fierce and independent tribes of savages. It leaves the great trunk between the 3d and 6th degree of southern latitude, and runs eastward from the *Paramo* or high desert of Tuquillo and St Martin, and the sources of the Guaviari, rearing the lofty summits of Umama and Canavami, and pouring forth the large rivers Meta, Zama, and Ymerida, which form the *roudals* or tremendous rapids of Aturé and Maypuré, the only openings existing at present between the interior of the continent and the plain of the Amazons. Beyond these cataracts the chain of mountains again acquires greater elevation and breadth, occupying the vast tract inclosed between the rivers Caura, Cavony, and Padamo, and stretching southward to the boundless forests where the Portuguese settlers gather that potent drug the *sarsaparilla.* Farther eastward this chain is not traced, no European or civilized Indian having ever explored the sources of the Orinoco; all access in that quarter being prevented by the ferocity of the Guaicas, a dwarfish but very fair and warlike race, and by the valour of the Guajaribos, a most desperate tribe of cannibals. Beyond these recesses, however, we are made acquainted with the continuation of the chain of the cataracts, by the astonishing journey performed by Don Antonio Santos, who, disguised like a savage, his body naked, and his skin stained of a copper colour, and speaking fluently the several Indian dialects, penetrated from the mouth of the Rio Caronis to the Lake of Parimé and the Amazons. The range of mountains sinks lower, and contracts its breadth to 200 miles, where it assumes the name of Serrania de Quimeropaca and Pacaraimo. A few degrees farther eastward it spreads out again, and bends south to the Canno Pirara along the Mao, near whose banks appears the Cerro or hill of Ucucuamo, consisting entirely of a very shining and yellow mica slate, which has therefore procured from the credulity of early travellers the magnificent appellation of *Dorado* or Golden Mountain. East from the river Essequibo this Cordillera stretches to meet the granitic or gneiss mountains of Dutch and French Guiana, inhabited by confederated bands of negroes and Caribs, but giving birth to the commercial streams of Berbice, Surinam, and Maroni.

The chain of the cataracts of Orinoco has only a mean height of about 4000 feet above the level of the sea. The greatest elevation occurs where the mountain of Duida rears its enormous mass from the midst of a luxuriant plain, clothed with the tropical productions of palms and ananas, and discharges from its steep sides, about the close of the rainy season, volumes of incessant flames. No one has yet had the resolution or perseverance to climb through the tangling and rampant bushes to its peak, which, measured trigonometrically, gives an altitude of 8465 feet above the sea. The whole mountain group which forms this Cordillera is distinguished by the abrupt descent of its south flank; nor is it less remarkable for containing no rock of secondary formation, or exhibiting any vestige of petrifactions and organic remains. It contains only granite, gneiss, mica slate, and hornblende, without any casing or admixture of sandstone or calcareous matter.

The *third* great branch sent out from the trunk of the Andes is that of the *Chiquitos*, which province it traverses, making a sort of semicircular sweep between the parallels of 15 and 20 degrees south latitude, and appearing to connect the colossal heights of Peru and Chili with the mountains of Brazil and Paraguay. It supplies the rivers that feed the Maranon on the one side, and the Plata on the other. The structure and disposition, however, of the Cordillera of the Chiquitos still remain almost unknown.

These grand chains of mountains divide the southern continent of America, from the latitude of 19 to that of 52 degrees, into three immense plains, which on the west side are shut up by the enormous ridge of the Andes, but are all open on the east, and towards the Atlantic Ocean. The most northern is the valley of the Orinoco, consisting of savannahs or level tracts covered with reedy herbage and scattered palms. The next is the plain of the Maranon, which is entirely covered with dense, impenetrable forests. The third and southmost valley is the Pampas, a dead flat of most prodigious expanse, clothed, like that of the Orinoco, with a coarse, rank herbage, and abandoned to the occupation of countless herds of wild cattle.

Of these immense plains, the subsoil resembles the composition of the neighbouring mountains. In the valley of the Orinoco, the primitive rock is generally wrapt in a coat of sandstone, with calcareous cement, or covered with calcareous concretions, which betray the vestiges of recent organic remains, but show none of the older impressions, such as the belemnites and ammonites, so common in Europe. The woody plain of Maranon is distinguished by the thinness of its soil, and the total absence of any calcareous ingredients, the granite approaching close to the surface, which is in some places left quite bare over an extent of many furlongs. But the Pampas of Buenos Ayres are covered to a great depth with beds of alluvial deposites, in which the powers of vegetation, fomented by the rays of a burning sun, luxuriate in wanton profusion.

The lake of Titicaca covers a surface of 16,000 square miles, being in some places 70 or 80 fathoms deep. It has an elevation of 12,800 feet above the sea, and terminates at the mountain Potosi, which rises to 16,000 feet, and is yet covered with the ruins of the ancient Peruvian civilization. Near this centre the volcano of Antiquipa stands, at the height of 17,800 feet, while the double peak of the *Nevados*, or snowy Illimani, tower to the enormous elevations of 24,200 and 24,450 feet, or about 3000 feet above the summit of Chimborazo, which was long regarded as the loftiest pinnacle of our globe. But, in the northern extension of the Cordillera, Mount Sorata rears its snowy head, at the stupendous elevation of 25,000 feet.

In those tropical regions cultivation ascends to very near the limits of perpetual snow. Various prolific crops, and particularly wheat and potatoes, are grown at the height of 14,000 feet above the level of the sea. A considerable population, dispersed in towns or villages, occupy tracts about 1000 feet higher, and enjoy health and vigour in a keen atmosphere, twice as rare as at the level of the sea. The ancient Peruvians had worked some gold mines at the vast altitude of 17,000 feet.

The disciple of Werner traces with delight, in the majestic features of the American continent, the same order and succession of rocks which the sagacity of that illustrious geologist had discovered in the mountains of Saxony. Granite appears still the oldest material of our globe: to it succeeds the laminated species, or gneiss; then mica slate, containing garnets; next primitive slate, with beds of native alum; now slate mixed with hornblende; above this greenstone or primitive trap, followed by amygdaloid; and last of the series, porphyry slate. Resting or flanked against those primary rocks, beds of

the older limestone begin to appear, followed by a suite of minerals bearing indications of organic remains—mica slate, hornblende, gypsum, and calcareous sandstone. The only formations which Humboldt did not meet with, in his extensive travels, were those of chalk, roestone, graywacke, topaz rock, and the compound of serpentine with granular limestone which occurs in Asia Minor. The grand ridge of the Andes is everywhere covered with porphyry, basalt, phonolite, and greenstone; which being often broken into columns, appear at a distance like ruined castles, and produce a very striking effect. Near the bottom of that enormous chain, two different sorts of limestone occur; one with a silicious base, inclosing sometimes cinnabar and coal; and another mostly calcareous, and cementing the secondary rocks. These formations are of enormous thickness and elevation. "Beds of coal are found in the neighbourhood of Santa Fé, 8650 feet above the level of the sea; and even at the height of 14,700, near Huanco in Peru. The plains of Bogota, although elevated 9000 feet, are covered with gypsum, sandstone, shell-limestone, and even in some parts with rock salt. Fossil shells, which in the old continent have not been discovered higher than the summits of the Pyrenees, or 11,700 feet above the sea, were observed in Peru, near Micuipampa, at the height of 12,800 feet; and again at that of 14,120, beside Huancavelica, where sandstone also appears. The basalt of Pichincha, near the city of Quito, has an elevation of 15,500 feet, while the top of the Schneekoppe in Silesia is only 4225 feet above the sea—the highest point in Germany where that species of rock occurs. On the other hand, granite, which in Europe crowns the loftiest mountains, is not found in the American continent above the height of 11,500 feet. It is scarcely known at all in the provinces of Quito and Peru. The frozen summits of Chimborazo, Cayambé, and Antisana, consist entirely of porphyry, which, on the flanks of the Andes, forms a mass of 10,000 or 12,000 feet in depth. The sandstone near Cuença has a thickness of 5000 feet, and the stupendous mass of pure quartz on the west of Caxamarca measures perpendicularly 9600 feet. It is likewise a remarkable fact, that the porphyry of those mountains very frequently contains hornblende, but never quartz, and seldom mica.

"The central Andes are rich beyond conception in all the metals, lead only excepted. One of the most curious ones in the bowels of those mountains is the *pacos*, a compound of clay, oxyde of iron, and the muriate of silver with native silver. The mines of Mexico and Peru, so long the objects of envy and admiration, far from being yet exhausted, promise, under a liberal and improved system, to become more productive than ever. But nature has blended with those hidden treasures the active elements of destruction. The whole chain of the Andes is subject to the most terrible earthquakes. From Cotopaxi to the South Sea no fewer than forty volcanoes are constantly burning; some of them, especially the lower ones, ejecting lava, and others discharging the muriate of ammonia, scorified basalt, and porphyry, enormous quantities of water, and especially *moya*, or clay mixed with sulphur and carbonaceous matter. Eternal snow invests their sides, and forms a barrier to the animal and vegetable kingdoms. Near that confine the torpor of vegetation is marked by dreary wastes." (*Edinb. Review*, vol. xv. p. 233.)

We may subjoin that, near Quito, the liquid mud ejected by the volcanoes often involves myriads of small dead fish. In some parts, the mountains, like the fabled cave of Æolus, seem at times to let out their imprisoned air, and produce such furious gusts of wind as to sweep every thing before them to a vast distance. In other districts, the efforts of the contending elements are betrayed, especially during the rainy season, by a doleful moaning noise, or hollow and portentous groans, enough to cast a darker shade on the gloom of superstition, and to fill the imagination of the remotest settler with secret awe and dread.

A person who for the first time climbs the mountains of Switzerland is astonished to witness, in the space perhaps of a few hours, so rapid a change of climate, and such a wide range of vegetable productions. He may begin his ascent from the midst of warm vineyards, and pass through a succession of chesnuts, oaks, and beeches, till he gains the elevation of the hardy pines and stunted birches, or treads on Alpine pastures, extending to the border of perpetual snow. But within the tropics every thing is formed on a grander scale. The boundary of permanent congelation is 7500 feet higher at the equator than at the mean latitude of 45 degrees. Under a burning sun ananas and plantains grow profusely near the shore; oranges and limes occur a little higher; then succeed fields of maize and luxuriant wheat; and the traveller has actually reached the high plain of Mexico, or the still loftier vale of Quito, before he finds a climate analogous to that of Bordeaux or of Geneva. Now only commences the series of plants which inhabit the central parts of Europe.

But the very magnitude of the Andes appears to have the effect of diminishing the impressions of awe and wonder which the sight of them so powerfully excites. The country on which they rest is heaved to such a vast altitude above the sea, that the relative elevation of their summits becomes diminished in comparison with that of the surrounding amphitheatre. The majestic forms of Chimborazo, Cotopaxi, and Antisana, though 6000 feet higher than Mont Blanc, and clothed, like it, with eternal snow, seem to a traveller scarcely more sublime from the plains of Riobomba and Quito, than the celebrated mountain when viewed from the vale of Chamouni. It requires some time for his imagination to expand itself to the new scale of grandeur.

The central Andes, with all their magnificence, want a feature which, in the higher latitudes, contributes so much to the beauty and sublimity of the Alpine scenery. They have no vestige whatever of *glaciers*, those icy belts dropping from the limits of congelation, and spreading in concrete sheets, or hanging in disjointed columns fantastically thrown, which occur alike in the heart of Switzerland and on the northern shores of Norway and Lapland. This defect is evidently owing to the almost uniform temperature which prevails near the equator. In those torrid regions the days are constantly of the same length, and the sun shines through the whole year with very nearly equal force. The limit of perpetual congelation is hence marked on the sides of the mountains of Quito with singular precision. The temperature decreases regularly in proportion as one ascends them, till at a certain altitude it comes to the point of freezing, where the permanent field of snow begins to appear, defined with an almost unvarying border. But in the higher latitudes the sun remains during the summer so long above the horizon, and shines with such augmented force, that the heat of the atmosphere, and consequently of the surface of the ground, suffers a wide alteration in the different seasons. To the general investure of snow is therefore annexed every winter a zone of considerable breadth, which again softens and partly melts away during the continuance of the summer months. This alternate thawing and freezing occasions the production of glaciers, by converting successively the lower detached masses of snow in the precipitous flanks of the mountains, into a collection of broken and intermingled pillars of translucid ice.

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For the same reason, the Andes, though torn by flaming volcanoes, and convulsed by frequent and terrible earthquakes, are exempt from those *avalanches* and *eboulements* which in Switzerland and other mountainous parts of Europe often bury the helpless traveller in a torrent of snow, and batter down whole villages by the sudden discharge of a shower of rocks. Under the equator the variation of temperature throughout the year is so small as not to disturb the solidity of the vast collections of snow; but on the flanks of the Alps or Pyrenees, as the heat of the summer increases, portions of the upper field of snow become loosened, and, sliding down, put other masses likewise in motion, till spreading wider, and gaining accelerated force, the whole tide precipitates itself to the plain, sweeping all before it. Such is the accident of an *avalanche;* but the occurrence of an *eboulement*, though less frequent, is more tremendous. When the alternation of frost and thaw detaches a mass of rock, it rolls down the side of the mountain with resistless fury, shivering into fragments and tearing every thing opposed to it, overwhelming men, cattle, and houses, in one common heap of ruins.

But the Andes are distinguished from the chains of the European mountains by frightful *quebradas* or perpendicular rents, which form very narrow vales of immense depth, whose terrific walls, fringed below with luxuriant trees and shrubs, seem to lift their naked and barren heads to the distant skies. The noted crevices of Chota and Cutaco are nearly a mile deep, the former measuring 4950, and the latter 4300 feet, in a vertical descent. The task of crossing such tremendous gullies is often a work of infinite toil and extreme danger. In those mountainous countries travellers are accustomed to perform their journeys sitting in chairs fastened to the backs of men called *cargueros* or *carriers*. These porters are mulattoes, and sometimes whites, of great bodily strength and action, who will climb along the face of precipices, bearing loads of twelve and fourteen, or even eighteen stone. The *cargueros* lead a vagabond life, exposed to incredible fatigue, but recommended to them by its irregular course. Often those wretched men toil over mountains for the space of eight or nine hours every day, till, like beasts of burthen, they have their backs chafed and made quite raw with the load. In this deplorable condition they are not unfrequently abandoned by unfeeling travellers, and left alone to sicken, pine, or die in the forests. Yet their earnings would appear inadequate to such violent and overpowering exertions, since they receive scarcely three guineas for performing the journey from Ibague to Cartago, which requires fifteen, and perhaps twenty-five or thirty days.

The Icononzo, remarkable for its natural bridges, is a small *quebrada* or cleft of the mountains, through which flows the river of the Summa Paz, descending from the highest upland desert. The rocks consist of two different kinds of sandstone, the one extremely compact, and the other of a slaty texture, divided into their horizontal strata. The rent was probably caused by an earthquake, which the harder portion of the stony mass had resisted, and now connects the upper part of the chasm. This natural arch is 50 feet long, 40 broad, and 8 feet thick at the middle. Its height is about 300 feet above the surface of the torrent, which has a medium depth of twenty feet. About 60 feet below the natural bridge another smaller arch occurs, composed of three slanting blocks of stone wedged together, which had probably fallen from the roof at the same instant of time, and struck against the sides of the crevice in their descent.

The natural bridge of Icononzo has perhaps no counterpart in the old world; but the writer of this article had the pleasure of seeing, in early life, a similar phenomenon scarcely inferior to it in the United States of America. We allude to the famous arch described by Mr Jefferson, which crosses the Cedar creek in Rockbridge county, about a hundred miles beyond the Blue Ridge, in the higher district of Virginia. The divided rock is a pure limestone, leaving a chasm about 90 feet wide, of which the walls are 230 feet high, sprinkled with verdant bushes, and enamelled with gay flowers, among which the *aquilegia* is conspicuous. This bridge, viewed from a little distance below, has all the appearance of a Gothic arch; and is of such solidity, that loaded waggons used formerly to pass along it, till a more convenient line of road was formed.

In some places the natives of Peru connect the clefts of their mountains by pendulous bridges thrown fearlessly across, and suspended from both sides of a gap. They are composed of ropes made of the tough fibres of the *agavé*, hanging in a gently sloping curve, and covered with reeds or canes, with occasionally a narrow border of basket-work. The intrepid Indian, regardless of the horrors of the unfathomed abyss which yawns from below, commits himself to his frail and floating arch, and swiftly glides along its bending curvature, till he gains the opposite bank.

The Andes likewise give rise to waterfalls of immense height and amazing force. The cataract of Tequendama, considered in all its circumstances, exceeds any other in the known world. The basin which feeds its streams is the vast plain of Bogota, 7465 feet above the level of the sea, encircled completely with lofty mountains, except where the water, aided probably by the concussion of an earthquake, has cut for itself a narrow passage. The river Funcha, swelled by numerous feeders, gradually contracts its channel to the breadth of about 40 feet, and then gathering augmented force, dashes at two bounds from a perpendicular height of near 600 feet into a dark gulf. Owing to the excessive rapidity and depth of its current, it must discharge a prodigious volume of water, which quite stuns the ear by the roar of its crash; while it raises enormous clouds of thick spray and vapour, that continually bedew, and perhaps quicken, the vegetation of the adjacent grounds. Every thing conspires to exalt the beauty and grandeur of the scenery. "Independent of the height and mass of the column of water," says Humboldt, "the figure of the landscape, and the aspect of the rocks, it is the luxuriant form of the trees and herbaceous plants, their distribution into thickets, the contrast of those craggy precipices, and the freshness of vegetation, which stamp a peculiar character on these great scenes of nature." The transition from a temperate to a warm climate is rapid and surprising. The plain of Bogota bears rich crops of wheat, then succeed oaks and elms, intermingled with aralias, bigonias, and the yellow-bark trees; but immediately below the cataract a few palms appear, as if it were to mark the advance to a sultry soil.

A lively idea of the character and grand features of the Andes may be conceived from the account which the celebrated Humboldt has given of his journey across that majestic chain. Our readers will be glad to peruse it in the author's own words.

"The mountain of Quindiu, in the latitude of 4° 36′, is considered as the most difficult passage in the Cordilleras of the Andes. It is a thick uninhabited forest, which, in the finest season, cannot be traversed in less than ten or twelve days. Not even a hut is to be seen, nor can any means of subsistence be found. Travellers, at all times of the year, furnish themselves with a month's provision, since it often happens that, by the melting of the snows, and the sudden swell of the torrents, they find themselves so circumstanced that they can descend neither on the

side of Cartago nor that of Ibague. The highest point of the road, the Garito del Paramo, is 11,500 feet above the level of the sea. As the foot of the mountain, towards the banks of the Cauca, is only 3150 feet, the climate there is generally mild and temperate. The pathway, which forms the passage of the Cordilleras, is only 12 or 15 inches in breadth, and has the appearance, in several places, of a gallery dug and left open to the sky. In this part of the Andes, as almost in every other, the rock is covered with a thick stratum of clay. The streamlets which flow down the mountains have hollowed out gullies about 20 feet deep. Along these crevices, which are full of mud, the traveller is forced to grope his passage, the darkness of which is increased by the thick vegetation that covers the opening above. The oxen, which are the beasts of burden commonly used in this country, can scarcely force their way through these galleries, some of which are more than a mile in length; and if perchance the traveller meets them in one of these passages, he finds no means of avoiding them but by turning back and climbing the earthen wall which borders the crevice, and keeping himself suspended by laying hold of the roots which penetrate to this depth from the surface of the ground.

"We traversed the mountain of Quindiu in the month of October 1801, on foot, followed by twelve oxen, which carried our collections and instruments, amidst a deluge of rain, to which we were exposed during the last three or four days, in our descent on the western side of the Cordilleras. The road passes through a country full of bogs, and covered with bamboos. Our shoes were so torn by the prickles which shoot out from the roots of these gigantic gramina, that we were forced, like all other travellers who dislike being carried on men's backs, to go barefooted. This circumstance, the continual humidity, the length of the passage, the muscular force required to tread in a thick and muddy clay, the necessity of fording deep torrents of icy water, render this journey extremely fatiguing; but, however painful, it is accompanied by none of those dangers with which the credulity of the people alarms travellers. The road is narrow, but the places where it skirts the precipices are very rare.

"When travellers reach Ibague, and prepare to cross the forests of Quindiu, they pluck, in the neighbouring mountains, several hundred leaves of the vijao, a plant of the family of the bananas, which forms a genus approaching to the Thalia, and which must not be confounded with the *Heliconia Bibai*. These leaves, which are membranous and silky, like those of the *Musa*, are of an oval form, two feet long and 16 inches broad. Their lower surface is a silvery white, and covered with a farinaceous substance, which falls off in scales. This peculiar varnish enables them to resist the rain during a long time. In gathering these leaves, an incision is made in the middle rib, which is the continuation of the foot-stalk; and this serves as a hook to suspend them when the movable roof is formed. On taking it down, they are spread out, and carefully rolled up in a cylindrical bundle. It requires about an hundredweight of leaves to cover a hut large enough to hold six or eight persons. When the travellers reach a spot in the midst of the forests where the ground is dry, and where they propose to pass the night, the cargueros lop a few branches from the trees, with which they make a tent. In a few minutes this slight timber-work is divided into squares, by the stalks of some climbing plant, or the threads of the agavé placed in parallel lines 12 or 13 inches from each other. The vijao leaves meanwhile have been unrolled, and are now spread over the above work, so as to cover it like the tiles of a house. These huts, thus hastily built, are cool and commodious. If, during the night, the traveller feels the rain, he points out the spot where it enters, and a leaf is sufficient to obviate the inconvenience. We passed several days in the valley of Boquia, under one of those leafy tents, which was perfectly dry amidst violent and incessant rains."

For further information relative to the structure of the Andes, see the various sketches given by Humboldt, and particularly an abstract of his geological observations inserted in the *Journal de Physique*, vol. liii. for 1801. See likewise, by the same author, a memoir on the Geographic and Geognostic labours of M. Pentland, in the *Nouvelles Annales des Voyages et des Sciences Géographiques* for October, November, and December, 1829. (B.)

ANDEUSE, a city of Languedoc in France, situated in long. 3. 40. E. and lat. 43. 45. N.

ANDORRE, or Andorra, a valley on the Spanish side of the Pyrenees, of about 190 square miles in extent, containing 6 parishes, and which has ever been considered as neutral. It is a hilly district, with some good pasture for sheep, and several mines of iron, which are worked by the numerous rapid streams that pass through the district in their course towards Catalonia. It is a kind of independent republic, governed by two deputies chosen in each of the six parishes, and by two syndics. The expenses of governing are defrayed by a species of rent paid by owners of flocks, to the community, for the use of the pasture land. The king of France is called the protector in civil affairs, and the bishop of Urgel in ecclesiastical matters. It enjoys its peculiar criminal and civil laws and courts of justice. The chief judge is nominated alternately by the king of France and the bishop of Urgel, but there is no appeal to either France or Spain from his decisions. As the land does not produce sufficient corn for the supply of the inhabitants, a stipulated quantity is allowed annually to be introduced from France, for which permission a subsidy of 960 francs is granted to the king. The whole number of the inhabitants is about 15,000, who are neither French, nor Spaniards, nor Catalans, but speak a language containing a mixture of the three idioms. The council of state and the courts of justice assemble at the village of Andorra, and the former body retain the ancient Spanish title of cortes.

ANDOVER, a market and borough town in the hundred of the same name, in Hampshire. It is on the river Ande, 63 miles from London, on the great road to the west of England. It is a clean, well-built town, carrying on some trade in shalloons, and more in malt. It is connected with the sea by means of a canal, navigable to Southampton. Two members are returned to parliament, elected by the corporation, consisting of about 24 persons, who are said to be under the influence of Lord Portsmouth and Mr Etwall. Population in 1801, 3304; in 1811, 3701; and in 1821, 4123.

ANDRA, or Andros, a Turkish paschaliac, including the island of that name and the neighbouring islands of Tine, Mitone, Delos, Syra or Syros, Thermia Zea, and Hydra. The inhabitants are estimated at 96,800, almost wholly Greeks; the most industrious, and, exclusive of the effects of the present war, the most flourishing people of the Archipelago. There are some smaller islands included in the paschaliac, whose whole extent is 474 square miles. The island of Andros contains 12,000 inhabitants, mostly Greeks, who raise much silk, wine, and oil, and sufficient corn for their own consumption.

ANDRADA, Diego de Payva d', or Andradius, a learned Portuguese, born at Coimbra in 1528, who distinguished himself at the council of Trent, where King Sebastian sent him as one of his divines. He wrote several volumes of sermons, and other pieces; one of which, *De Conciliorum Autoritate*, was highly esteemed at Rome

Andrapodismus || Andrelinus.

on account of the great extension of authority which it gave to the pope. He died in 1575.

ANDRAPODISMUS, in ancient writers, the selling of persons for slaves. Hence also *andrapodistes*, a dealer in slaves, more particularly a kidnapper, who steals men or children to sell them,—a crime for which the Thessalians were noted.

ANDRAPODOCAPELI, in *Antiquity*, a kind of dealers in slaves. The *Andrapodocapeli* had a particular process for taking off moles and the like disfigurements on the faces of the slaves they kept for sale, by rubbing them with bran. At Athens, several places in the forum were appointed for the sale of slaves. Upon the first day of every month, the merchants called Ανδραποδοκαπηλοι brought them into the market and exposed them to sale: the crier, standing upon a stone erected for that purpose, called the people together.

ANDREAS, John, a celebrated canonist of the 14th century, was born at Magello, near Florence; and was professor of the canon law at Padua, Pisa, and afterwards at Bologna. He had a beautiful daughter, named *Novella*, whom he is said to have instructed so well in all parts of learning, that when he was engaged in any affair which hindered him from reading lectures to his scholars, he sent his daughter in his room; and, lest her beauty should prevent the attention of the hearers, she had a little curtain drawn before her. To perpetuate the memory of this daughter, he entitled his commentary upon the Decretals of Gregory IX. the *Novellæ*. He married her to John Calderinus, a learned canonist. The first work of Andreas was his Gloss upon the Sixth Book of the Decretals, which he wrote when he was very young. He wrote also Glosses upon the Clementines; and a Commentary *in Regulas Sexti*, which he entitled *Mercuriales*, because he either engaged in it on Wednesdays (*diebus Mercurii*), or because he inserted his Wednesday's disputes in it. He enlarged the Speculum of Durant in the year 1347. He died of the plague at Bologna in 1348, after he had been a professor 45 years, and was buried in the church of Dominicans.

Andreas, St, a market-town on the Danube, in the circle of Pilesch, and palatinate of Pest, in Hungary. It contains one Catholic and seven Greek churches, 1040 houses, and 7980 inhabitants, who trade very extensively in the wine produced in the vicinity. It is also the name of an island in the Danube, opposite to the town, which is fourteen miles in length and one in breadth, and remarkable for its great fertility.

ANDREASBERG, a bailiwick in the province of Grubenhagen, in the kingdom of Hanover. It extends over 87 square miles, or 55,680 acres, containing 4250 inhabitants, who are chiefly employed in mining. The soil is very poor, and affords scarcely any produce; but, like the rest of the Hartz forest, it abounds with metallic substances. The capital of the bailiwick is of the same name. It is 1880 feet above the level of the sea, on the declivity of the Hartz mountains, containing 400 houses, and 3206 inhabitants, who subsist chiefly by mining, whilst the females are employed in making lace. Near it is the Andreasberg silver mine, from which is produced annually about 40,000 ounces of silver, besides a large quantity of lead and copper, all of which are smelted in the town.

ANDRELINUS, Publius Faustus, born at Forli in Italy. He was a long time professor of poetry and philosophy in the university of Paris. Louis XII. of France made him his poet laureat, and Erasmus tells us that he was likewise poet to the queen. His pen was not wholly employed in making verses, for he wrote also moral and proverbial letters in prose, which were printed several times. His poems, which are chiefly in Latin, are inserted in vol. i. of the *Deliciæ Poetarum Italorum*. He died in 1518.

ANDRETTA, a town with 4049 inhabitants, in the province Principato Ulteriore of the kingdom of Naples.

ANDREW, St, the apostle, born at Bethsaida in Galilee, brother to Simon Peter. He had been a disciple of John the Baptist, and followed Jesus upon the testimony given of him by the Baptist. (John i. 35, 40, &c.) This was the first disciple whom our Saviour received into his train. Andrew introduced his brother Simon, and they passed a day with Christ, after which they went to the marriage in Cana (*ibid.* ii.), and at last returned to their ordinary occupation. Some months after, Jesus meeting them while they were both fishing together, called them to him, and promised to make them fishers of men. Immediately they left their nets, followed him (Matt. iv. 19), and never afterwards separated from him. After our Saviour's ascension, his apostles having determined by lot what parts of the world they should severally take, Scythia and the neighbouring countries fell to St Andrew, who, according to Eusebius, after he had planted the gospel in several places, came to Patræ in Achaia, where, endeavouring to convert the proconsul Ægeas, he was by that governor's orders scourged, and then crucified. The particular time of his suffering martyrdom is not known; but all the ancient and modern martyrologies, both of the Greeks and Latins, agree in celebrating his festival upon the 30th of November.

Andrew, or *Knights of St Andrew*, an order of knights, more usually called the Order of the Thistle.

Knights of St Andrew is also an order instituted by Peter the Great of Muscovy in 1698, the badge of which is a golden medal, on one side whereof is represented St Andrew's cross, with these words, *Czar Pierre, monarque de tout le Russie.* This medal being fastened to a blue ribbon, is suspended from the right shoulder.

St Andrew's Day, a festival of the Christian church, celebrated on the 30th of November in honour of the apostle St Andrew.

ANDREWS, St, a city of Scotland, in the county of Fife, pleasantly situated in a spacious bay of the German Ocean, into which flow the river Eden, the small rivulet of Kinness, and several other streams. It was formerly a place of much greater extent and importance. At present it is only about a mile and a half in circuit, and consists of three leading streets, intersected by a few considerable lanes. The principal street is well built, and is straight and broad, and of late years its appearance has been much improved. The town contains many interesting memorials of antiquity. Of the splendid cathedral, which was founded by Bishop Arnold in 1159, and attained to its highest magnificence in 1318, part of the east and west ends, and of the south side, are all that now remain. The length of this edifice from east to west was 350 feet within the walls; that of the transept 180 feet. This whole pile of building, which it took 150 years to complete, was in June 1559 demolished in a single day by John Knox and his infuriated followers. About 40 yards to the south-east is the chapel of St Regulus, the tower of which is a lofty square prism, the side of the base being 20 feet, and the height 108. The chapel to the east of the tower, which was the principal one, remains; but of a small chapel to the west, which formerly existed, there is now no trace. The arches of the windows and doors are round, and the figure of some of them is more than half of the circle, which is an undoubted proof of their antiquity. The priory, which was founded by Robert, bishop of St Andrews, during the reign of Alexander I. in 1120, was of great extent, and richly endowed. The prior had precedence of all abbots and priors, and on festival days had a right to wear a mitre and all episcopal ornaments. The walls of the pre-

cinct are all that now remain to mark the vast extent of this edifice. Part of the top of the great altar towards the east end of the cathedral was discovered between 30 and 40 years ago, in consequence of an excavation made in the hope of finding concealed treasure. At a much more recent period, the soil, which had for ages been permitted to accumulate, having been removed, part of the pavement was laid open, and several shafts of two rows of pillars parallel to each other, by which it is supposed that galleries in the inside of the walls had been supported. The other religious houses were, that of the Dominicans, founded in 1274 by Bishop Wishart; another of Observantines, founded by Bishop Kennedy, and finished by his successor Patrick Graham in 1478; and, according to some, the Carmelites had a fourth. Immediately above the harbour stood the collegiate church of Kirk-heugh, originally founded by Constantine III., who, retiring from the world, became here a Culdee. From its having been first built on a rock, it was styled *Præpositura Sanctæ Mariæ de Rupe.*

On the east side of the city are the remains of the castle, on a rock overlooking the sea. This fortress was founded about the year 1200, by Roger, one of the bishops of St Andrews, and was repaired towards the end of the 14th century by Bishop Trail, who died in it in 1401. He was buried near the high altar of the cathedral, with this singular epitaph:

> Hic fuit ecclesiæ directa columna, fenestra
> Lucida, thuribulum redolens, campana sonora.

The castle was the residence of Cardinal Beaton, who, after the cruel execution of the celebrated reformer George Wishart in front of it, was afraid of the fury of the people; and his knowledge of this, joined to his apprehension of an invasion from England, induced him to strengthen the fortifications, with a view of rendering the castle impregnable. In this fortress he was surprised and assassinated by Norman Lesley, aided by fifteen others. Early in the morning of May 29, 1546, they seized on the gate of the castle, which had been left open for the workmen who were finishing the fortifications; and having placed sentinels at the door of the cardinal's apartment, they awakened his numerous domestics one by one, and, turning them out of the castle, without violence, tumult, or injury to any other person, inflicted on Beaton the death he justly merited. The conspirators were immediately besieged in this castle by the regent, earl of Arran; and although their strength consisted of only 150 men, they resisted his efforts for five months, owing more to the unskilfulness of the attack than the strength of the place, for in 1547 the castle was reduced and demolished, and its picturesque ruins serve as a land-mark to mariners. The entrance to the castle, and the window out of which it is said Cardinal Beaton leaned to witness the cruel martyrdom of George Wishart, are still pointed out.

The parish church is a spacious structure, 162 feet in length by 63 in breadth, and is large enough to accommodate 2500 persons. It contains a lofty monument of white marble, erected in honour of Archbishop Sharpe, who, in revenge for his oppressive conduct, was murdered by some of the exasperated reformers of that day. On this monument is a rude piece of sculpture representing the tragical scene of the murder. To the north is situated the college church, which belongs to the united college of St Salvator and St Leonard. It was founded in 1458 by Bishop Kennedy, and contains a beautiful tomb of its founder, who died in 1466; which is a fine specimen of the Gothic architecture of that period. About the year 1683, on opening this tomb, six highly ornamented silver maces were discovered, which had been concealed there in times of trouble, three of which are still preserved in the university, and three were sent to the other universities of Scotland. On the top is represented our Saviour; around are angels with the instruments of his passion. With these are shown some silver arrows, with large silver plates affixed to them, on which are inscribed the arms and names of those who were victors in the annual competitions of archery, which were regularly held until within these few years. Golf is now the reigning game. That sport, and foot-ball, were formerly prohibited by an act of parliament passed in the reign of James II. in 1457, as interfering too much with the acquisition of dexterity in archery, an accomplishment in those days of much consequence to the safety of the state. The statute has been long obsolete, and the inhabitants, and the students who attend the university, have full permission to enjoy this elegant amusement.

The celebrated university of this city was founded in 1411 by Bishop Wardlaw. It consisted formerly of three colleges. 1. St Salvator's was founded in 1458 by Bishop Kennedy. This was a handsome building, with a court or quadrangle, which is 230 feet long by 150 wide, and a gateway surmounted by a spire 156 feet high. On one side is the church; on another what was the library of St Salvator's; the third contains apartments for students; the fourth is unfinished. The buildings connected with the college being in a state of great decay, a grant has been made by government for erecting a new structure. Part of this building will soon be finished, and the remainder, it is expected, will be immediately after commenced. When it is completed it will be in a high degree elegant and commodious. 2. St Leonard's College was founded by Prior Hepburn in 1522. This is now united with the last, and the buildings sold, and converted into private houses. 3. New or St Mary's College was established by Archbishop Hamilton in 1552; but the house was completed by Archbishop Beaton. This is said to have been the site of a celebrated school long before the establishment even of the university, where several eminent clergymen taught gratis the sciences and languages; but it was called the *New College*, because of its late erection into a divinity college by the archbishop. The buildings of this college have been substantially repaired, and with great taste.

The university is governed by a chancellor,—an office which it was originally intended should be permanently exercised by the archbishop of St Andrews. Subsequent to the Reformation, the chancellor has been elected by the two principals and the professors of both colleges.

The rector is the next great officer, to whose care are committed the privileges, discipline, and statutes of the university. The colleges have their principals, and professors of different sciences, who are indefatigable in their attention to the instruction and the morals of the students. The place possesses, in its pure and salubrious air, and in its extensive grounds for exercise, very great advantages for the education of youth. In St Salvator's College are taught the languages, philosophy, and the sciences. St Mary's, which stands in a different part of the town, is reserved exclusively for theology. The classes and discipline of the two colleges are quite distinct, each having its respective principal and professors. They have a common library, which is entitled to a copy of every work entered in Stationers Hall, and which now (1830) contains upwards of 40,000 volumes. An addition has been in the course of last season made to the library, which was much required, in consequence of the great increase of the number of books.

Seventy-five bursaries or endowments belong to the

St Andrews.

university, and are conferred on the students. Of these, 58 belong to the United, and 17 to the New College. The number of students at St Andrews never exceeded 300 at any period. During the present year (1830) they amount to 190 at both colleges—149 at the United College, 41 at St Mary's.

The trade of St Andrews was once very considerable. So late as the reign of Charles I. it had thirty or forty trading vessels, and carried on a considerable herring and white fishery, by means of busses, in deep water, which had for ages been a most profitable branch of commerce, and a source of wealth. During the troubles which followed the death of this monarch, this whole coast, and St Andrews in particular, became a scene of murder and rapine; and every town suffered in proportion to its magnitude and opulence. St Andrews was required to pay a contribution of L.1000, which the inhabitants, after being plundered, were not able to raise: a composition of L.500 was accepted, which was raised by a loan at interest, and has remained a burden upon the corporation, it is believed, ever since.

The harbour of St Andrews is artificial: it is guarded by piers, and is safe and commodious; but it is difficult of access, having a narrow entrance, and being exposed to the east winds, which raise a heavy sea on the coast. The shore of the bay is low; and, in the storms of winter, vessels are frequently driven on it and lost.

St Andrews had a manufactory of sail-cloth to some extent, but it is now discontinued. The game of golf being much practised here, there is a manufactory of golf balls, which, after supplying the home consumption, sends about 9000 annually to other parts. The shipping of the port consists of about eleven vessels, which are employed in the coasting trade. St Andrews is a royal borough, uniting with Cupar, Perth, Dundee, and Forfar, in returning a member to parliament.

According to early traditions, St Andrews owes its origin to a Greek monk, Regulus, who having been warned in a vision to visit Albion, was shipwrecked in the bay about the end of the fourth century. He was hospitably received, according to these ancient accounts, by the king, who presented him with his own palace, and built near it the church of St Regulus, the remains of which are still to be seen. At this time the place was styled *Mucross*, or the *land of boars*. All around was forest, and the lands bestowed on the saint were called *Byrehid*. The boars equalled in size the ancient Erymanthian; as a proof of which, two tusks, each sixteen inches long and four thick, were chained to the altar of St Andrew. The king changed the name to *Kilrymont*, and established here the first Christian priests of the country, called *Culdees*. The church was supreme in the kingdom of the Picts, Hungus having granted to God and St Andrew that it should be the head and mother of all the churches in his dominion. He also directed that the cross of St Andrew should become the badge of the country. In 818, after the conquest of the Picts, he removed the episcopal see to St Andrews, and the bishop was styled *maximus Scotorum episcopus*. In 1471 it was erected into an archbishopric by Sextus IV. at the intercession of James III. In 1606 the priory was suppressed; and in 1617 the power of election was transferred to eight bishops, the principal of St Leonard's College, the archdeacon, the vicars of St Andrews, Leuchars, and Cupar. This see contained the greater part of the shire of Fife, with a part of the counties of Perth, Forfar, and Kincardine, and a great number of parishes, churches, and chapels in other dioceses.

The town of St Andrews was erected into a royal borough by David I. in the year 1140, and its privileges afterwards confirmed. The charter of Malcolm II., written on a small bit of parchment, is preserved in the tolbooth. Here also are kept the silver keys of the city, which, for form's sake, are delivered to the king if he should visit the place, or to a victorious enemy in token of submission. In this place, likewise, is to be seen the enormous axe with which, in 1646, Sir Robert Spotswood and other distinguished loyalists were beheaded. The town underwent a siege in 1337, at which time it was possessed by the English and other partisans of Baliol; but the loyalists, under the earls of March and Fife, made themselves masters of it in three weeks, by the help of their battering machines. It is 9 miles E. of Cupar, and 39 N. N. E. of Edinburgh. The population, according to the last census, was 4899. Long. 2. 50. W. Lat. 56. 19. 33. N. (F.)

ANDREWS, James Pettit, a late English historian and miscellaneous writer, was the younger son of Joseph Andrews, Esq. of Shaw-house, near Newbury, Berks, where he was born in the year 1737. He was educated privately, and is said to have discovered an early taste for literature and the fine arts. He joined the Berkshire militia when they were first called out, being then about 18 or 19, and held the rank of lieutenant in that regiment until it was disbanded. On the institution of the new system of London police, he was appointed one of the commissioners for the district of Queen's Square and St Margaret's, Westminster, and discharged the duties of that office with great industry and integrity until his death, which took place at his house in London, on the 6th of August 1797, in the 60th year of his age. He married Miss Ann Penrose, daughter of the Rev. Mr Penrose, late rector of Newbury, by whom he had two sons and a daughter. He seems to have possessed a cheerful and social disposition, and enjoyed the conversation of a large circle of literary acquaintance, who frequently met at his house and experienced his hospitality.

Mr Andrews appears to have devoted a considerable portion of his time to literary pursuits; and he is the author of several works which are not undeserving of notice. The first publication upon which we find him employed is an edition of the poems of his friend and relation Penrose, in 1781; to which he prefixed an introduction, containing a short account of the life and character of the author. His first original production, so far as we have been able to ascertain, was a pamphlet in behalf of the chimney-sweepers' apprentices in 1788, which is said to have led to the act of parliament passed not long afterwards for the purpose of ameliorating the condition of that unfortunate class of beings. In 1789 he published *Anecdotes, Ancient and Modern*, 8vo, a work of pleasantry, in the composition of which he acknowledged having received assistance from the late laureat Mr Pye, the facetious antiquary Captain Grose, and others. To this volume he added a Supplement in 1790.

The most extensive work undertaken by Mr Andrews was his *History of Great Britain, connected with the Chronology of Europe; with Notes*, &c. The first volume, which commences with Cæsar's invasion, and ends with the deposition and death of Richard II., was published in 1794 in 4to. A second volume, in which the history is continued from the deposition and death of Richard II. to the accession of Edward VI., appeared in 1795. The plan of this work is new, and in some respects singular; a certain portion of the history of England is given on one page, and a corresponding portion of the contemporaneous history of Europe on the one opposite. The notes consist of a variety of curious and amusing particulars, not immediately connected with the main story. Appendixes are also added at proper intervals, containing an account of the state of literature, science, religion, government, man-

ners, &c. at different periods. The author, however, did not live to complete this curious and extensive work, no more of it having appeared than the two volumes above mentioned. In 1796 he published a continuation of Henry's *History of Britain*, in one volume 4to and two volumes 8vo.

The other productions of this author are, *An Account of Saxon Coins found in Kintbury Churchyard, Berks*, printed in the seventh volume of the *Archæologia;* the *Account of Shaw*, in Mr Mores's Berkshire Collections; *The Savages of Europe*, a popular French novel, which he translated, and illustrated by prints from his own designs. Mr Andrews was also a frequent contributor to the *Gentleman's Magazine*. See the *Gen. Biog. Dict.* by Chalmers; *Introduction to Poems by the Rev. Thomas Penrose*, 1781; *Gent. Mag.* for 1797 and 1801; and Lysons' *Supplement to Environs of London*, 1811. (K.)

ANDREWS, *Lancelot*, bishop of Winchester, was born at London in 1555, and educated at Cambridge. After several preferments he was made bishop, first of Chichester, then of Ely, and in 1610 was raised to the see of Winchester. This very learned prelate, who was distinguished by his piety, charity, and integrity, may be justly ranked with the best preachers and scholars of his age. He appeared, however, to much greater advantage in the pulpit than he does now in his works, which abound with Latin quotations and trivial witticisms. He died at Winchester House in Southwark, September 27, 1626, in the 71st year of his age, and was buried in the parish church of St Saviour's, where his executors erected to him a very fair monument of marble and alabaster, on which is an elegant inscription in Latin, written by one of his chaplains. His most popular works are, his *Sermons*, his *Lectures on the Ten Commandments*, and his *Orphan Lectures*, each forming a folio volume. There is a collection by Felix Kyngston, of some other pieces written by him, which was published in 4to in 1629.

ANDRIA, in *Grecian Antiquity*, public entertainments first instituted by Minos of Crete, and, after his example, appointed by Lycurgus at Sparta, at which a whole city or a tribe assisted. They were managed with the utmost frugality, and persons of all ages were admitted.

ANDRIA, a city and a bishop's see in the territory of Bari, in the kingdom of Naples. It is pretty large, well peopled, and seated in a spacious plain, four miles from the Adriatic coast. Long. 17. 4. E. Lat. 41. 15. N.

ANDRISCUS, a man of mean extraction, who, pretending to be the son of Perseus, last king of Macedonia, took upon him the name of *Philip*, for which reason he was called *Pseudo-Philippus*, the *False Philip*. After a complete victory over Juventus, the Roman pretor who was sent against him, he assumed kingly power, but exercised it with vast cruelty. At last the Romans obliged him to fly into Thrace, where he was betrayed and delivered into the hands of Metellus. This victory placed Macedonia once more in the power of the Romans, and gained for Metellus the name of Macedonicus, but cost the Romans 25,000 men. Andriscus adorned the triumph of Metellus, walking in chains before the general's chariot.

ANDROGEUS, in *Fabulous History*, the son of Minos, king of Crete, was murdered by the Athenian youth and those of Megara, who envied his being always victor at the Attic games. But Minos having taken Athens and Megara, obliged the inhabitants to send him an annual tribute of seven young men and as many virgins, to be devoured by the Minotaur. From this tribute they were delivered by Theseus.

ANDROGYNES, in *Ancient Mythology*, creatures of whom, according to the fable, each individual possessed the powers and characters of both sexes, having two heads, four arms, and two feet. The word itself is compounded of two Greek radical words; ανηρ, in the genitive ανδρος, a *male;* and γυνη, a *female*. Many of the rabbinical writers pretend that Adam was created double, one body being male, the other female, which in their origin not being essentially joined, God afterwards did nothing but separate them.

ANDROGYNES, in *Natural History*, a name given to those living creatures which, by a monstrous formation of their generative parts, seem (for it is only seeming) to unite in themselves the two sexes, that of the male and of the female. See HERMAPHRODITE.

ANDROIDES, in *Mechanics*, a human figure, which, by certain springs or other movements, is capable of performing some of the natural motions of a living man. The motions of the human body are more complicated, and consequently more difficult to be imitated, than those of any other creature; whence the construction of an *androides*, in such a manner as to imitate any of these actions with tolerable exactness, is justly supposed to indicate a greater skill in mechanics than any other piece of workmanship whatever.

A very remarkable figure of this kind appeared in Paris in the year 1738. It represented a flute-player, and was capable of performing different pieces of music on the German flute; which, considering the difficulty of blowing that instrument, the different contractions of the lips necessary to produce the distinctions between the high and low notes, and the complicated motions of the fingers, must appear truly wonderful.

This machine was the invention of M. Vaucanson, member of the Royal Academy of Sciences; and a particular description of it was published in the Memoirs of the Academy for that year.

The figure itself was about $5\frac{1}{2}$ feet in height, situated at the end of an artificial rock, and placed upon a square pedestal $4\frac{1}{2}$ feet high and $3\frac{1}{2}$ broad. The air entered the body by three pipes separated one from the other. It was conveyed to them by nine pairs of bellows, three of which were placed above and six below. These were made to expand and contract regularly in succession by means of an axis of steel turned round by some clockwork. On this axis were different protuberances at proper distances, to which were fixed cords thrown over pulleys, and terminating in the upper boards of the bellows, so that, as the axis turned, these boards were alternately raised and let down. A contrivance was also used to prevent the disagreeable hissing fluttering noise usually attending the motion of bellows. This was by making the cord by which the bellows was moved press, in its descent, upon one end of a smaller lever, the other end of which ascending, forced open the small leathern valve that admitted the air, and kept it so till, the cord being relaxed by the descent of the upper board, the lever fell, and the air was forced out. Thus the bellows performed their functions constantly without the least hissing, or other noise by which it could be judged in what manner the air was conveyed to the machine. The upper boards of three of the pairs of bellows were pressed down by a weight of 4lbs., those of three others by a weight of 2lbs., and those of the three remaining ones by nothing but their own weight.

The three tubes by which the air entered terminated in three small reservoirs in the trunk of the figure. There they united, and, ascending towards the throat, formed the cavity of the mouth, which terminated in two small lips adapted in some measure to perform their proper functions. Within this cavity also was a small movable tongue, which, by its play, at proper periods admitted the air, or intercepted its passage to the flute.

Androides. The fingers, lips, and tongue, received their proper directions by means of a steel cylinder turned by clock-work. It was divided into 15 equal parts, which, by means of pegs pressing upon the ends of 15 different levers, caused the other extremities to ascend. Seven of these levers directed the fingers, having wires and chains affixed to their ascending extremities, which being attached to the fingers, caused them to ascend in proportion as the other extremity was pressed down by the motion of the cylinder, and *vice versa*. Thus the ascent or descent of one end of a lever produced a similar ascent or descent in the corresponding finger, by which one of the holes of the flute was occasionally opened or stopped, as by a living performer. Three of the levers served to regulate the ingress of the air, being contrived so as to open and shut, by means of valves, the three reservoirs of air above mentioned, so that more or less strength might be given, and a higher or lower note produced, as occasion required. The lips were, by a similar mechanism, directed by four levers, one of which opened them, to give the air a freer passage; the other contracted them; the third drew them backward; and the fourth pushed them forward. The lips were projected upon that part of the flute which receives the air; and, by the different motions already mentioned, modified the tone in a proper manner. The remaining lever was employed in the direction of the tongue, which it easily moved so as to shut or open the mouth of the flute.

Thus we see how all the motions necessary for a flute-player could be performed by this machine; but a considerable difficulty still remains, namely, how to regulate these motions properly, and make each of them follow in just succession. This, however, was effected by the following simple method: the extremity of the axis of the cylinder was terminated on the right side by an endless screw, consisting of twelve threads, each placed at the distance of a line and a half from the other. Above this screw was fixed a piece of copper, and in it a steel pivot, which, falling in between the threads of the screw, obliged the cylinder to follow the threads, and instead of turning directly round, it was continually pushed to one side. Hence, if a lever was moved by a peg placed on the cylinder in any one revolution, it could not be moved by the same peg in the succeeding revolution, because the peg would be moved a line and a half beyond it by the lateral motion of the cylinder. Thus, by an artificial disposition of those pegs in different parts of the cylinder, the statue was made, by the successive elevation of the proper levers, to exhibit all the different motions of a flute-player, to the admiration of every one who saw it.

The construction of machines capable of imitating even the mechanical actions of the human body shows exquisite skill; but what shall we say of one capable, not only of imitating actions of this kind, but of acting as external circumstances require, as though it were endued with life and reason? This, nevertheless, has been done. M. de Kempelen, a gentleman of Presburg in Hungary, excited by the performances of M. de Vaucanson, at first endeavoured to imitate them, and at last far excelled them. This gentleman constructed an androides capable of playing at chess! Every one who is in the least acquainted with this game must know that it is so far from being mechanically performed, as to require a greater exertion of the judgment and rational faculties than is sufficient to accomplish many matters of greater importance. That this machine really was made, however, the public have had ocular demonstration. The inventor came over to Britain in 1783, where he remained above a year with his automaton.

It is a figure as large as life, in a Turkish dress, sitting behind a table, with doors of three feet and a half in length, two in depth, and two and a half in height. The chair on which it sits is fixed to the table, which runs on four wheels. The automaton leans its right arm on the table, and in its left hand holds a pipe: with this hand it plays after the pipe is removed. A chess-board of 18 inches is fixed before it. This table, or rather cupboard, contains wheels, levers, cylinders, and other pieces of mechanism, all which are publicly displayed. The vestments of the automaton are then lifted over its head, and the body is seen full of similar wheels and levers. There is a little door in its thigh, which is likewise opened; and with this, and the table also open, and the automaton uncovered, the whole is wheeled about the room. The doors are then shut, and the automaton is ready to play; and it always takes the first move.

At every motion the wheels are heard; the image moves its head, and looks over every part of the chess-board. When it checks the queen it shakes its head twice, and thrice in giving check to the king. It likewise shakes its head when a false move is made, replaces the piece, and makes its own move; by which means the adversary loses one.

M. de Kempelen remarks as the most surprising circumstance attending his automaton, that it had been exhibited at Presburg, Vienna, Paris, and London, to thousands, many of whom were mathematicians and chess-players, and yet the secret by which he governed the motion of its arm was never discovered. He prided himself solely in the construction of the mechanical powers, by which the arm could perform ten or twelve moves. It then required to be wound up like a watch, after which it was capable of continuing the same number of motions.

The automaton could not play unless M. de Kempelen or his substitute was near it to direct its moves. A small square box, during the game, was frequently consulted by the exhibiter; and herein consisted the secret, which he said he could in a moment communicate. He who could beat M. de Kempelen was, of course, certain of conquering the automaton. It was made in 1769. His own account of it was, "C'est une bagatelle qui n'est pas sans mérite du côté du méchanisme; mais les effets n'en paroissent si merveilleux que par la hardiesse de l'idée, et par l'heureux choix des moyens employés pour faire illusion." See AUTOMATON.

ANDROLEPSY, in *Grecian Antiquity*, an action allowed by the Athenians against such as protected persons guilty of murder. The relations of the deceased were empowered to seize three men in the city or house whither the malefactor had fled, till he should be either surrendered, or satisfaction made some way or other for the murder.

ANDROMACHE, the wife of Hector, the mother of Astyanax, and daughter of Eetion king of Thebes in Cilicia. After the death of Hector and the destruction of Troy she married Pyrrhus, and afterwards Helenus the son of Priam, with whom she reigned over part of Epirus.

ANDROMEDA, in *Astronomy*, a northern constellation, behind Pegasus, Cassiopeia, and Perseus. It represents the figure of a woman chained, and is fabled to have been formed in memory of Andromeda, daughter of Cepheus and Cassiopeia, and wife of Perseus, by whom she had been delivered from a sea monster, to which she had been exposed to be devoured for her mother's pride. Minerva translated her into the heavens.

ANDRON, in *Grecian Antiquity*, denotes the apartment in houses designed for the use of men; in which sense it stands opposed to *Gynæceum*.—The Greeks also gave their dining-rooms the title of *andron*, because the women had no admittance to feasts with the men.

ANDRONA, in ancient writers, denotes a street or public place where people met and conversed together. In some writers *androna* is more expressly used for the space between two houses; in which sense the Greeks also use the term ανδρωνας for the way or passage between two apartments.

ANDRONA is also used, in ecclesiastical writers, for that part in churches destined for the men. Anciently it was the custom for the men and women to have separate apartments in places of worship, where they performed their devotions asunder; which method is still religiously observed in the Greek church. The ανδρων, or *androna*, was in the southern side of the church, and the women's apartment on the northern.

ANDRONICUS I. COMNENUS, emperor of the East, was the son of Isaac, and grandson of Alexius Comnenus. Naturally active, martial, and eloquent, he shines as one of the most conspicuous characters of his age. Following the bent of his inclination, he attended the Roman army in their retreat; but in their march through Asia Minor, wandering into the mountains, he fell into the hands of some Turkish huntsmen, was carried to the sultan, and remained his prisoner; but regaining his liberty, both his virtues and vices soon recommended him to the favour of his cousin Manuel, the reigning emperor. The vicious heart of Andronicus manifested itself clearly in maintaining a licentious correspondence with Eudocia, the emperor's niece, while the emperor himself lived in public incest with her sister Theodora. His martial spirit gained him a considerable command in Cilicia, where he laid siege to Mopsuestia; but by a successful sally of the enemy he was obliged to raise the siege, and retire in considerable disorder. Inflamed with a desire of revenging the infamy of their sister in his blood, the brothers of Eudocia made an unsuccessful attempt to assassinate Andronicus at midnight in his tent; but being awakened, he defended himself with surprising bravery, forced his way through his enemies, and escaped in safety. Afterwards engaging in a treasonable correspondence with the emperor of Germany and the king of Hungary, he was arrested and thrown into confinement. He remained in this state about twelve years, and after several repeated attempts to escape, he at last effected his purpose, and fled for refuge to the court of the great duke of Russia. The cunning of Andronicus soon found means to regain his favour with the emperor Manuel; for having exerted all his influence, he succeeded in obtaining the Russian prince to engage to join his troops with those of Manuel, in the invasion of Hungary. Accordingly, on account of his important service, he obtained a free pardon from the emperor, and after an expedition to the Danube returned with him to Constantinople. He again fell under the displeasure of the emperor, by refusing to take an oath of allegiance to the prince of Hungary, his intended son-in-law, and consequently presumptive heir to the crown, and was thereupon returned to his former command in Cilicia. While residing here, his powerful address captivated the heart of Philippa, daughter of the Latin prince of Antioch, and sister to the empress Maria; and in her company he spent his time in all the amusements that country could afford, till the emperor's resentment put a stop to their correspondence. Thus circumstanced, he collected a band of adventurers, and undertook a pilgrimage to the Holy Land, where, by his insinuating turn of mind, he so far succeeded in gaining the favour of the king and clergy, as to be invested with the lordship of Berytus, on the coast of Phœnicia. In this neighbourhood Theodora, the beautiful widow of Baldwin, king of Jerusalem, and nearly allied in blood to him, resided. The personal accomplishments and address of Andronicus captivated her heart, and she became the third victim to his artful seduction, and lived publicly as his concubine. Still pursued by the emperor with unabating resentment, he was forced to take refuge in Damascus, and then in several other places in the east, till at length he settled in Asia Minor. While residing here he made frequent incursions into the province of Trebizond, and seldom returned without success. After several occurrences Theodora was made captive by the governor of Trebizond, along with her two children, and sent to Constantinople; upon which Andronicus implored and obtained pardon. He acted the affected penitent in such a manner, that he again ingratiated himself into the favour both of the church and state; but was sent to dwell at Œnoe, a town situated on the Euxine coast.

In the year 1177 Manuel died, and was succeeded by his son Alexius II., a youth about twelve or fourteen years of age, without wisdom or experience, by which the ambition of Andronicus was again called into action. A civil war having been occasioned by the misconduct of the empress in Constantinople, the public mind was directed towards Andronicus, as the only person whose rank and accomplishments could restore the public tranquillity. Incited by the patriarchs and patricians, he marched towards Constantinople, which he entered, took possession of the palace, confined the empress, consigned her minister to death, assumed the office of protector, put to death many persons of distinction, tried and executed the queen on a charge of corresponding with the king of Hungary, and vowed fidelity to the young emperor upon his coronation, at the same time teaching the necessity of an experienced ruler, to assuage the evils that threatened the empire; upon which his adherents called out, "Long live Alexius and Andronicus, Roman emperors." While he affected reluctance, he was elevated to a partnership in the empire. This conjunction of the royal power was soon dissolved by the murder of the unfortunate Alexius. The body of the deceased being brought into his presence, striking it with his foot, he said, "Thy father was a knave, thy mother a whore, and thyself a fool." Having arrived at the dignity of sole emperor, A. D. 1183, he continued to sway the sceptre with a mixture of justice and bounty towards his subjects at large; but those whom he feared or hated he governed with the most cruel tyranny. The noble families that were either cut off or exiled by him were all allied to the Comneni. Some of these were engaged in revolt; and the public calamity was heightened by an invasion of the Sicilians, in which they took and sacked Thessalonica. A rival without merit, and a people without arms, at last overturned his throne. A descendant from the first Alexius in the female line, named Isaac Angelus, being singled out by Andronicus as a victim to his cruelty, he with courage and resolution defended his life and liberty, slew his executioner, fled to the church of St Sophia, and there took refuge with several of his friends. Isaac was instantly raised by the populace from a sanctuary to a throne. When this event took place Andronicus was absent from Constantinople; but he no sooner heard of it than he with the utmost speed returned. Upon his arrival there he found himself deserted by all, and was seized and dragged in chains before the new emperor. All the eloquence he displayed was of no avail; for Isaac delivered him into the hands of those whom he had injured, and for the space of three days he endured with uncommon patience all the insults and torments that were inflicted upon him. At last two friendly or furious Italians, plunging their swords into his body, put a period to his life. His death, in the 73d year of his age, terminated the dynasty of the Comneni.

ANDRONICUS of Cyrrhus, an Athenian astronomer, built

Androphagi || Andrychow.

at Athens an octagon tower, with figures carved on each side, representing the eight principal winds. A brazen Triton at the summit, with a rod in its hand, turned round by the wind, pointed to the quarter from whence it blew. From this model is derived the custom of placing weathercocks on steeples.

ANDROPHAGI, in *Ancient Geography*, the name of a nation whose country, according to Herodotus, was adjacent to Scythia. Their name, compounded of two Greek words, signifies *man-eaters*. See ANTHROPOPHAGI.

ANDROS, one of the ancient Cyclades, lying between Tenos and Eubœa, being one mile distant from the former, and ten from the latter. The ancients gave it various names, viz. Cauros, Lasia, Nonagria, Epagris, Antandros, and Hydrusia. The name of *Andros* it received from one Andreus, appointed, according to Diodorus Siculus, by Rhadamanthus, one of the generals, to govern the Cyclades after they had of their own accord submitted to him. It had formerly a city of great note, bearing the same name, and situated very advantageously on the brow of a hill which commanded the whole coast. In this city, according to Strabo and Pliny, stood a famous temple dedicated to Bacchus. Near this temple Mutianus, as quoted by Pliny, tells us there was a spring called the *gift of Jupiter*, the water of which had the taste of wine in the month of January, during the feast of Bacchus, which lasted seven days. The Andrians were the first of all the islanders who joined the Persians when Xerxes invaded Greece; and therefore Themistocles, after the victory at Salamis, resolved to attack the city of Andros, and oblige the inhabitants to pay large contributions for the maintenance of his fleet. Having landed his men on the island, he sent heralds to the magistrates, acquainting them that the Athenians were coming against them with two powerful divinities, Persuasion and Force, and therefore they must part with their money by fair means or foul. The Andrians replied that they likewise had two mighty deities, who were very fond of their island, viz. Poverty and Impossibility, and therefore could give no money. Themistocles, not satisfied with this answer, laid siege to the town, which he probably made himself master of and destroyed, as we are informed by Plutarch that Pericles, a few years after, sent thither a colony of 250 Athenians. It was, however, soon retaken by the Persians, and, on the overthrow of that empire by Alexander the Great, submitted to him, along with the other islands. On his death it sided with Antigonus, who was driven out by Ptolemy. The successors of the last-mentioned prince held it till the time of the Romans, when Attalus, king of Pergamus, besieged the metropolis at the head of a Roman army, and, having taken it, was by them put in possession of the whole island. Upon the death of Attalus the republic claimed this island, as well as his other dominions, in virtue of his last will.

Andros is now subject to the Turks, and contains a town of the same name, with a great many villages. It is the most fruitful island in the Archipelago, and yields a great quantity of silk. Andros, when visited by Tournefort, contained about 4000 inhabitants. There were seven monasteries, a great number of churches, and a cathedral for the bishops of the Roman Catholic persuasion; but most of the inhabitants were of the Greek communion. It forms a part of the new Greek republic. It is about 23 miles long and 6 broad. Long. 24. 50. E. Lat. 37. 50. N.

ANDRUM, a kind of hydrocele, to which the people of Malabar are very subject. It is said to be derived from the bad quality of the country waters, impregnated with certain salts.

ANDRYCHOW, a city in the circle of Myslenicze, in the Austrian province of Galizia, on the river Wieprzowka, with a castle, and 2805 inhabitants, amongst whom are several manufacturers of fine damask and other table-linen, who produce annually about 30,000 pieces.

ANDUJAN, a city of Spain, in the province of Jaen, in Andalusia. It is situated on the south side of the Sierra Morena, which defends it from the cold winds of the north, near the sources of the Jandula. There is a very fine bridge over the Guadalquivir at this place. The surrounding country is well watered, and yields abundant harvests of wheat, barley, oil, and wine; and numerous hives of bees furnish abundant supplies of honey and wax. From a whitish clay found here there are manufactured a vast quantity of jars called alcarrasas, which are highly esteemed for their property of keeping water cool in the hottest summer weather. It contains a castle, six churches, nine monasteries, a theatre, and 14,000 inhabitants. Long. 3. 28. 25. W. Lat. 38. 1. 32. N.

ANDUZE, a town of France, in the department of the Gard, seated on the river Gardon. It carries on a considerable trade in serges and woollen cloth. Long. 3. 42. E. Lat. 43. 39. N.

ANECDOTES (*Anecdota*), a term used by some authors for the titles of *Secret Histories;* but it more properly denotes a relation of detached and interesting particulars. The word is Greek, ανεκδοτα, signifying *things not yet known* or *hitherto kept secret*. Procopius gives this title to a book which he published against Justinian and his wife Theodora. Anecdotes is also an appellation given to such works of the ancients as have not yet been published; in which sense Muratori gives the name *Anecdota Græca* to several writings of the Greek fathers, found in the libraries, and first published by him. Martene and Durand have given a *Thesaurus novus Anecdotorum*, in 5 vols. folio.

ANEMOMETER, or ANEMOSCOPE, machines for measuring the force, and indicating the course, of the wind. See WIND-GAGE.

ANEMUR, the most southern point of Asia Minor, on the south coast of Caramania. The castle of Anemur stands six miles east of the cape, on the edge of the sea, and extends about 800 feet by 300. Its citadel is placed on a small rocky eminence, and is in a ruinous state. Long. 32. 30. E. Lat. 36. 15. N.

ANGAR, ANGAN, or HINDSHAM, a barren and uninhabited island on the Arabian shore of the Persian Gulf, on the south side of the island of Kishma, about 12 miles in circuit. It must have been formerly inhabited, as it contains the ruins of a considerable town, and many reservoirs of water. It has also two wells, and a stream of good water, which unfortunately become dry in the hot weather. It is covered with pits of salt and metallic ores, and a soft rocky substance resembling lava. The hills, which are overspread with shells of oysters and other fish, abound in wild goats, rabbits, and partridges.

ANGARA, a river of Siberia, which has its rise in the Lake Baikal. It passes the town of Irkutsk with a rapid course, and receiving the Oka, it changes its name to Toungooska, and falls into the Yenesei or Jenesei after a course of 700 miles. It is navigable, and is noted for the clearness of its waters.

ANGARI, or ANGARII, in *Antiquity*, public couriers, appointed for the carrying of messages. The ancient Persians, Budæus observes, had their αγγαρειον δρομημα, which was a set of couriers on horseback, posted at certain stages or distances, always in readiness to receive the dispatches from one, and forward them to another, with wonderful celerity, answering to what the moderns call *posts* (*positi*), as being posted at certain places or stages. The angari were also called by the Persians *astandæ;* by the Greeks ἡμεροδρομοι, on account of the long journeys

they made in one day, which, according to Suidas, amounted to not less than 1500 stadia.

ANGARIA, in *Roman Antiquity*, a kind of public service imposed on the provincials, which consisted in providing horses and carriages for the conveyance of military stores and other public burdens. It is sometimes also used for a guard of soldiers, posted for the defence of a place. In a more general sense it is used for any kind of oppression, or services performed through compulsion.

ANGAZYA, one of the Comora Islands, lying between the north end of Madagascar and the coast of Zanguebar in Africa, from lat. 10. to 15. S. It is inhabited by Moors, who trade with divers parts of the continent, in cattle, fruits, and other commodities of the island, which they exchange for calicoes and other cotton cloths.

ANGEIOTOMY, in *Surgery*, implies the opening of a vein or artery, as in bleeding; and consequently includes both arteriotomy and phlebotomy.

ANGEL, a spiritual intelligent substance, the first in rank and dignity among created beings. The word *angel* is Greek, and signifies a *messenger:* the Hebrew מלאך signifies the same thing. The angels are in Daniel, chap. iv. ver. 13, &c. called עירים, or *watchers*, from their vigilance: for the same reason they are, in the remains we have of the prophecy attributed to Enoch, named *Egregori;* which word imports the same in Greek.

The term *Angel*, therefore, in the proper signification of the word, does not import the nature of any being, but only an office; in which sense angels are called the *ministers of God*, and *ministering spirits*. That there are such beings, invisible and imperceptible to our senses, endued with understanding and power superior to those of human nature, created by God, and subject to him,—ministering to his divine providence in the government of the world,—are truths fully attested by Scripture. Nay, the existence of such invisible beings was generally acknowledged by the heathens, though under different appellations: the Greeks called them *demons*, and the Romans *genii* or *lares*. Epicurus seems to have been the only one among the ancient philosophers who absolutely rejected them.

As to the nature of these beings, we are told that they are spirits; but whether pure spirits divested of all matter, or united to some corporeal vehicles, has been a controversy of long standing. Not only the ancient philosophers, but some of the Christian fathers, were of opinion that angels were clothed with ethereal or fiery bodies, of the same nature with those which we shall one day have when we come to be equal to them. But the more general opinion, especially of later times, has been, that they are substances entirely spiritual, though they can at any time assume bodies, and appear in human or other shapes.

Besides their attendance on God, and their waiting and executing his commands, they are also presumed to be employed in taking care of mankind and their concerns: and that every man had such a tutelar or guardian angel, even from his birth, was a firm belief and tradition among the Jews; and our Saviour himself seems to have been of the same sentiment. The heathens were also of that persuasion, and thought it a crime to neglect the admonitions of so divine a guide. The Romans thought the tutelar genii of those who attained the empire to be of an eminent order, on which account they had great honours shown them. Nations and cities also had their several genii. The ancient Persians so firmly believed the ministry of angels, and their superintendence over human affairs, that they gave their names to their months, and the days of their months, and assigned them distinct offices and provinces: and it is from them the Jews confess to have received the names of the months and angels, which they brought with them when they returned from the Babylonish captivity; after which, we find they also assigned charges to the angels, and in particular the patronage of empires and nations; Michael being the prince of the Jews, as Raphael is supposed to have been of the Persians.

Angelics || Anger.

Of the fallen angels.

Although the angels were originally created perfect, good, and obedient to their Master's will, yet some of them sinned and kept not their first estate, but left their habitation, and so, from the most blessed and glorious, became the most vile and miserable, of all God's creatures. They were expelled the regions of light, and cast down to hell, to be reserved in everlasting chains under darkness, until the day of judgment. With heaven they lost their heavenly disposition, which delighted once in doing good and praising God; and fell into a settled rancour against the Deity, and malice against men. Their inward peace was gone; all desire of doing good departed from them, and instead thereof, revengeful thoughts and despair took possession of them, and created an eternal hell within them.

ANGELICS, Angelici, in *Ecclesiastical History*, an ancient sect of heretics, supposed by some to have got this appellation from their excessive veneration of angels; and by others, from their maintaining that the world was created by angels.

Angelics is the name of an order of knights, instituted in 1191, by Angelus Flavius Comnenus, emperor of Constantinople: also of a congregation of nuns, founded at Milan in 1534, by Louisa Torelli, countess of Guastalla. They observe the rule of St Augustin.

ANGELITES, in *Ecclesiastical History*, a sect of Christian heretics in the reign of the emperor Anastasius, and the pontificate of Symmachus, about the year 494; so called from Angelium, a place in the city of Alexandria where they held their first meetings. They were called likewise *Severites*, from one Severus, who was the head of their sect; as also *Theodosians*, from one among them named Theodosius, whom they made pope at Alexandria. They held that the persons of the Trinity are not the same; that none of them exists of himself, and of his own nature, but that there is a common god or deity existing in them all, and that each is God, by a participation of this deity.

ANGELO, Michael. See *Buonaroti, Michael Angelo.*

Angelo, St, a small but strong town of Italy, in the Capitanata. There are several other towns and castles of the same name in Italy, and particularly the castle of St Angelo at Rome. Long. 15. 56. E. Lat. 41. 43. N.

ANGELOT, an ancient English gold coin, struck at Paris while under subjection to the English. It was thus called from the figure of an angel supporting the scutcheon of the arms of England and France. There was another coin of the same denomination struck under Philip de Valois.

Angelot is also used in *Commerce* to denote a small, fat, rich sort of cheese brought from Normandy. Skinner supposes it to have been thus called from the name of the person who first made it up in that form, and perhaps stamped it with his own name. Menage supposes it to have been denominated from the resemblance it bears to the English coin called *angelot*. It is made chiefly in the Pays de Bray, whence it is also denominated *angelot de Bray*. It is commonly made in vats, either square or shaped like a heart.

ANGER, a painful feeling of the mind, excited by the receipt of an injury or affront, and accompanied with a disposition to retaliate on the author of the injury. Bishop Butler observes that anger is far from being a selfish passion, since it is produced by injuries offered to others as well as to ourselves, and was designed by the Author of nature not only to excite us to act vigorously in defending ourselves from evil, but to interest us in the defence or

Angerburg ‖ Angers.

rescue of the injured and helpless, and to raise us above the fear of the proud and mighty oppressor.

The same author makes an important distinction, as Dr Reid observes (*Active Powers*, Essay 3), "between sudden anger or resentment, which is a blind impulse arising from our constitution, and that which is deliberate. The first may be raised by hurt of any kind; but the last can only be raised by injury, real or conceived. Both these kinds of anger or resentment are raised whether the hurt or injury be done to ourselves or to those we are interested in."

Physicians and naturalists have recorded instances of extraordinary cases produced by anger. Borrichius cured a woman of an inveterate tertian ague, which had baffled the art of physic, by putting the patient in a furious fit of anger. Valeriola made use of the same means, with the like success, in a quartan ague. The same passion has been equally salutary to paralytic, gouty, and even dumb persons; to which last it has sometimes given the use of speech. Etmüller gives divers instances of very singular cures wrought by anger: among others, he mentions a person laid up by the gout, who being provoked by his physician, flew upon him, and was cured. It has often, on the other hand, been productive of fatal effects. We meet with several instances of princes to whom it has proved mortal, *e. g.* Valentinian the First, Wenceslaus, Matthias Corvinus, king of Hungary, and others. There are also instances where it produced epilepsy, jaundice, cholera morbus, diarrhœa, &c.

ANGERBURG, a circle in the government of Gumbinnen, or province of East Prussia, formerly a part of Poland. It extends over 374 square miles, or 239,360 acres. It is watered by the Angerap, which rises in several lakes, with which the district abounds. The inhabitants are 21,172, who produce some corn and flax, and much fresh-water fish and fire-wood. The females are all employed in spinning linen yarn. The capital is of the same name, and contains 250 houses and 2619 inhabitants.

ANGERMANLANDS-LAPMARK, or ÆSLE-LAPMARK, a province in the northern part of Sweden, of the vast extent of 6560 square miles. The inhabitants are only 1200, partly Laplanders, with a few Swedes denominated colonists. The chief productions to spare are butter and some iron wares. Æsle is the chief place, and besides it there are two parishes with churches.

ANGERMUNDE, a circle in the government of Potsdam, and province of Brandenburg, in Prussia. It extends over 503 square miles, or 321,920 acres; and comprehends six cities, three market-towns, 109 villages, and 4201 dwellings, with 34,896 inhabitants. The river Oder washes its eastern boundary, and receives the several smaller streams by which it is watered. The borders of the rivers present some excellent meadow-land, on which many cattle are pastured. It produces good corn, tobacco, flax, and abundance of garden fruit. There is much wood land, and several lakes which yield fish in great plenty. The capital, of the same name, contains three churches, 291 houses, and 2654 inhabitants, whose chief occupation is making snuff and tobacco.

ANGERONA, in *Mythology*, the name of a pagan deity whom the Romans prayed to for the cure of the *quinsy*, in Latin *angina*. Pliny calls her the *goddess of silence* and *calmness of mind*, who banishes all uneasiness and melancholy. She is represented with her mouth covered, to denote patience and refraining from complaints. Her statue was set up and sacrificed to in the temple of the goddess Volupia, to show that a patient enduring of affliction leads to pleasure.

ANGERS, an arrondissement in the department of the Mayenne and Loire, in France, extending over 436 square miles, or 279,040 acres. It is divided into seven cantons, and those again into 59 communes, containing 92,810 inhabitants. The chief city, of the same name, contains 33,100 inhabitants.

ANGHIERA, a town of Italy, in the duchy of Milan, and capital of a county of the same name. It is seated on the eastern side of the lake Maggiore, in lat. 45. 42. N. long. 8. 40. E.

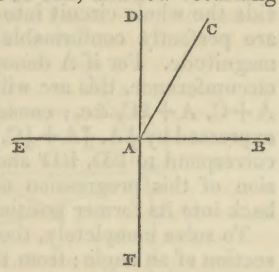
ANGLE. This term is, owing to the poverty of language, employed to signify very different things. In Plane Geometry, it means the opening or separation of two straight lines which meet in a point; but in Solid Geometry, it variously denotes the deviation of a straight line from a plane, the divergence of one plane from another at their line of junction, or even a cluster of plane angles terminating in a common summit. This diversified application of the same word is not likely, however, among mathematicians, to occasion any misconception. But it would be more perspicuous, and certainly more philosophical, to imitate the practice of naturalists in framing a set of cognate words to express the several transitions of meaning.

The word *angle* was drawn from common discourse into the vocabulary of science. Its primitive sense, in all the languages in which it can be traced, is merely a *nook* or *corner*; but it has acquired a more precise and extensive application in its transfer to geometry. In its simplest form, it now denotes generally the *divergence* or difference of direction between two concurring straight lines. Yet a learner still experiences some difficulty in seizing the correct idea of its nature, which has always baffled the attempts of authors to reduce to the terms of a strict definition. Apollonius, at once the most elegant and inventive of the Greek geometers, was satisfied with representing an angle as a *collection of space about a point*,—a description which is not only extremely loose, but which intimates quite a different conception. Euclid, the great compiler of the *Elements*, has defined an angle to be the κλισις, or *mutual inclination of two straight lines that meet*. But, in strict language, this definition should apply only to the acute angle, in which one of the sides leans towards the other, and deflects from the perpendicular. Without an extension of the meaning of the term *inclination*, it will not include the obtuse angle, and far less comprehend angles in general; which, since they are capable of repeated additions, must evidently, as much as lines themselves, be susceptible of all degrees of magnitude.

It is indeed impossible, by any combination of words, to express completely and accurately the primary notions which form the ground of geometrical science. The more profitable task is to trace the process by which the mind, refining on external observation, comes to acquire such abstract ideas. We seem to get the idea of *length*, or of *linear extension*, by viewing *progressive* motion; and the enlarged conception of *angles*, or of *angular magnitude*, is easily attained, from the contemplation of *revolving* motion. In opening, for instance, the legs of a pair of compasses, we perceive that their difference in direction gradually increases, keeping pace with the turning at the joint. The quantity of this opening properly constitutes the measure of an angle; and an entire revolution, which brings the moving side of the angle back to its first position, furnishes a *standard* of reference. The bisected revolution marks the divergence of a directly opposite position, or that of two segments of a straight line at their point of separation; and the half of this, again, or the divergence of a line proceeding from the same point, and turned equally aside from both segments, is the *right angle*, which, therefore, being constant, serves to measure all the rest.

Suppose an inflexible straight line AB to turn from right

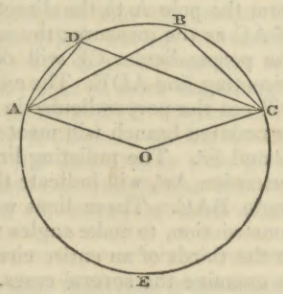
to left, about the point or vertex A. It first comes to the position AC, then to AD, next to AE, and now returning it reaches AF, and lastly it gains its original site AB. The angles thus formed at the point A arise from the combination of successive openings. The angle BAD is composed of BAC and CAD; the angle BAE, or that of direct opposition, is compounded of BAC, CAD, and DAE; and the entire circuit is made of the accumulated angle BAC, CAD, DAE, EAF, and FAB. This circuit, being quartered by the straight lines BE and DF, is divided at the vertex A into four right angles. By comparison, therefore, the angle BAC is acute, and CAE obtuse.



But the side AB can attain the direction AC either by moving onwards, or by turning backwards through the points F, E, and D. The angle compounded of the openings BAF, FAE, EAD, and DAC, may hence be termed appropriately the *reverse* of BAC. The defect of an angle from a right angle is called its *complement*, the defect from two right angles its *supplement*, and the defect from four right angles, or the entire circuit, might be conveniently named its *explement*. Thus, CAD is the *complement* of the angle BAC, CAE is its *supplement*, and the reverse angle BAC its *explement*.

If we consider attentively the formation of angles about a point, we shall be convinced that two concurring straight lines do not contain merely a single angle, but involve an indefinite multitude of angles; in short, that they comprehend all the revolutions and parts of a revolution by which the one line would successively attain the direction of the other. Hence AB will, after describing repeated revolutions, always return into the same position AC. Thus, if A represent the measure of an angle, and C that of a whole circuit, or four right angles; then the primary angle will include likewise A+C, A+2C, A+3C, A+4C, continued for ever. Of those successive angles, A, A+C, A+2C, A+3C, A+4C, &c. the sines, tangents, and secants are severally the same; and so are the versed sines, the cosines, cotangents, and cosecants. This extension of the doctrine of angles is of the greatest importance in the higher branches of geometry, in the application of trigonometrical formulæ, and in algebraical analysis.

Euclid, in the course of his reasoning, has frequent occasion to combine angles together; and yet he never ventures beyond the consideration of those angles which are less than two right angles. Had he composed his *Elements* after the science of trigonometry came to be cultivated, he could not have failed to take more enlarged views of angular magnitude. In consequence of his narrow conception of the constitution of angles, the Greek geometer is not a little cramped sometimes, and obliged to adopt a circuitous mode of demonstration. For instance, in the 20th prop. of his third book, that "the angles at the circumference are the halves of those at the centre standing on the same arc," he quite overlooks the case of obtuse angles at the circumference. But, in the annexed figure, the angle ABC is clearly the half of the *reverse* angle AOC at the centre, which is subtended by the large arc AEC. It hence follows that the obtuse angles ABC and ADC contained in the same segment must be equal, since they are both of them halves of the same *reverse* angle AOC. Yet, in demonstrating this very obvious corollary, Euclid is constrained to divide the obtuse angles into portions which are shown to be the halves of corresponding angles at the centre. For the same reason he finds it necessary to give a distinct demonstration of the celebrated proposition, that "the angle contained in a semicircle is a right angle." But this property ought likewise to be considered as a mere corollary; for if the radii OA and OC were supposed to extend in one straight line, and thus form the diameter of the circle, their angle AOC would become equal to two right angles, and consequently ABC, its half, would be one right angle. See Leslie's *Geometry*. (B.)



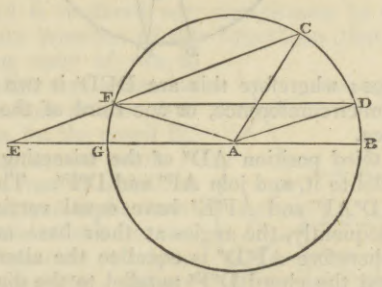
Angle of Incidence, in *Optics*, the angle which a ray of light makes with a perpendicular to that point of the surface of any medium on which it falls; though it is sometimes understood of the angle which it makes with the surface itself.

Angle of Refraction now generally means the angle which a ray of light, refracted by any medium, makes with a perpendicular to that point on the surface of which it was incident; but has sometimes been understood of the angle which it makes with the surface of the refracting medium itself.

Angle, *Trisection of*. The attempts of the Greek mathematicians to *Double a Cube*, and to *Trisect an Angle*, were their first steps beyond the limits of elementary geometry. They soon perceived that such problems cannot be solved by any combination of mere straight lines or circles. To this conclusion they were led directly by the application of *geometrical analysis*, a beautiful instrument of discovery which Plato had recently invented or improved. Their investigations pointed at some curves of a higher order than the circle, and opened to them a wide and interesting field of research.

The analysis of the trisection of an angle, conducted in two different ways, terminates in the construction of the *conchoid*, a complex curve which was first proposed by Nicomedes. As the subject is very curious, and throws great light on the theory of angular magnitude, we shall here not only give both the ancient methods of investigation, but subjoin a third which is due to the sagacity of Newton.

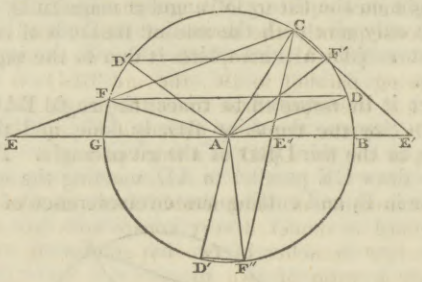
I. Let it be required to trisect the angle BAC or the arc BC. Suppose the thing already done, and the angle BAD to be the third part of the given angle. From the point C draw CE parallel to AD, meeting the extended diameter in E, and cutting the circumference of the circle in the point F; join FD and FA. It is obvious that the angle BAD is the half of DAC, the remaining part of the whole angle, and therefore equal to the angle DFC at the circumference. But AD and EC being parallel, the angle BAD is equal to AEF, which is hence equal to DFC; and consequently FD is parallel to EB. Wherefore the arc BD is equal to GF, and the angle BAD equal to GAF. The angle AEF is thus equal to EAF, and hence the side EF is equal to AF, the radius of the circle.



To solve the problem, therefore, it would be requisite to inflect from C a straight line CFE, such, that the portion FE, intercepted between the circumference and the diameter, or its extension, should be equal to the radius of the circle. The radius AD, drawn parallel to this inflected line CE, would cut off an angle BAD, which is the third part of the given angle BAC.

But elementary geometry will not in general furnish the means of inflecting CE, according to the required conditions. This must be done either tentatively, that is, by repeated trials, or by the application of a curve, so constituted that every straight line drawn from the *pole* C to the *directrix* BG shall have the portion EF, intercepted by the curve, equal to AB. This curve is, from its general shape or resemblance to a *conch* or shell, named the *conchoid:* it consists of two branches, one above the directrix called the *interior conchoid*, and the other below it called the *exterior conchoid.* The conchoid being described, will, by its intersection with the circumference of the circle, give the point F, and consequently the position of the trisecting line AD′. But such a complex curve must cut the circumference in more points than one, and consequently the problem of angular trisection, viewed in its generality, admits of several answers. In fact, there are always *three* distinct positions of the inflected line CE, which will fulfil the conditions of the problem.

It is curious to examine these different positions of the inflected line. Draw AD′ parallel to the *second* position CE′, and join D′F, AD′, and AF′. Because AF′ is equal to E′F′, the angle E′AF′ is equal to AE′F′; and, consequently, the exterior angle AF′C is the double of either of these. But CAF′ being an isosceles triangle, AF′C is equal to ACF′, which again is equal to the alternate angle CAD′; wherefore CAD′ is the double of the angle AE′F′; and being likewise the double of CF′D′ at the circumference, the angles CF′D′ and AE′F′ are equal, and, consequently, F′D′ and E′A parallel. Now the angle CAD′ being double of E′AF′ or D′AG, and the angle CAD double of DAB, the arc DCD′ is double of the arcs D′G and DB, which serve to complete the semicir-

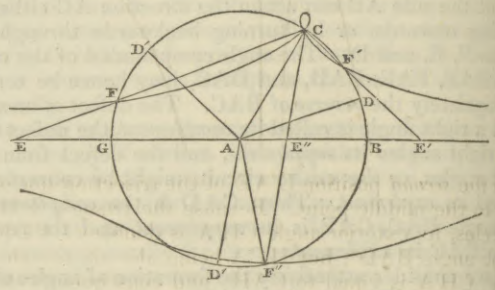


cumference; wherefore this arc DCD′ is two third parts of the semicircumference, or one third of the whole circumference.

In the *third* position AD″ of the trisecting line, draw CF″ parallel to it, and join AF″ and D″F″. The isosceles triangles D″AF″ and AF″E″ have equal vertical angles; and, consequently, the angles at their base are likewise equal; wherefore AF″D″ is equal to the alternate angle F″AE″, and the chord D″F″ parallel to the diameter BG. But the reverse angle CAD″ standing on the arc CD′D″ is double of the angle CF″D″ at the circumference, and therefore double of BE″F″ or of BAD″; and the angle CAD being by the first construction likewise double of BAD, the reverse angle CAD″, together with CAD, must be double of BAD″ and BAD, or the arc CD′GD″ is double of DBD″, which completes the circumference. Hence the arc DD′D″ is two thirds of the circumference.

It thus appears that the construction of the problem assumes three different aspects, and that the trisecting lines, to which a close analogy conducts us, mutually divide the whole circuit into equal portions. These results are perfectly conformable with the theory of angular magnitude. For if A denote the arc BC, and C the whole circumference, this arc will be generally expressed by A, A+C, A+2C, &c.; consequently, the third part will be expressed by $\frac{1}{3}$A, $\frac{1}{3}$A+$\frac{1}{3}$C, $\frac{1}{3}$A+$\frac{2}{3}$C, &c., which evidently correspond to BD, BD′ and BD″. But any farther extension of this progression only brings the trisecting line back into its former positions.

To solve completely, therefore, the problem of the trisection of an angle; from the pole C, on either side of the directrix BG, with a measure equal to the radius of the circle, describe the exterior and the interior or nodated conchoid; draw CF, CF′, and CF″ to the three points of intersection with the circumference, and the radii AD,

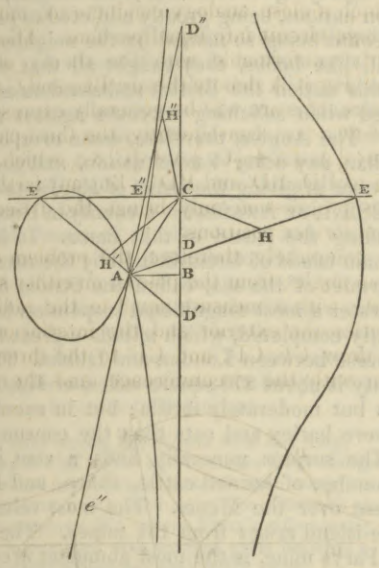


AD′, and AD″ parallel to these will mark the triple section of the angle BAC.

It may be perceived that the exterior branch of the conchoid cuts the under semicircle in another point besides F. This occurs in the extension of the radius CA, or where the diameter passing through C, the extremity of the original arc, meets the opposite circumference; the portion of the inflected line, intercepted below BG by the conchoid, being evidently equal to the radius. The fourth intersection, however, affords no real solution, but only exhibits the amount of repeated division, as completing the arc itself.

2. But another analysis leads to a similar result. Let the angle BAD, as before, be the third part of BAC; draw BC perpendicular to AB, and CE parallel to it, meeting AD produced in E. The right angle DCE would be contained in a semicircle having DE for its diameter; join C with the centre H, and the triangle CHE being isosceles, the exterior angle CHA is double of CEH, or of the alternate angle BAD, and therefore equal to the remaining portion CAD of the divided angle BAC. Whence the triangle ACH is isosceles, and the side CA equal to HC, or the diameter DE must be double of AC.

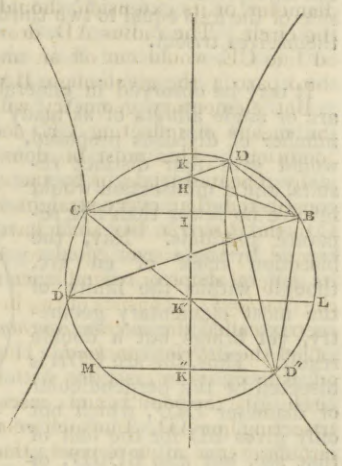
The construction of the problem is thus reduced to the drawing from the vertex of the given angle a straight line ADE, such, that the part DE, intercepted between the perpendiculars BC and CE, shall be equal to the double of AC. This can only be done by describing a conchoid from the pole A to the directrix BC, and with the double of AC as the measure; the intersection of the curve with the perpendicular CE will determine the position of the trisecting line ADE. The exterior branch of the conchoid will cut the perpendicular in the point E, and the interior or nodated branch will meet and cross it at the two points E′ and E″. The radiating lines AE, AE′, and AE″, or its extension Ae″, will indicate the complete trisection of the angle BAC. These lines will be found, as in the first construction, to make angles with each other that are equal to the thirds of an entire circuit. It may be worth while to examine the several cases.



In the *second* position D′AE′ of the trisecting line, draw CH′ to the middle point. Because the triangle E′H′C is isosceles, its exterior angle CH′A is double of CE′H′, or of the angle BAD′; but H′CA being also an isosceles triangle, CH′A is equal to CAH′, and consequently double of BAD. Add CAD, which is double of BAD, and the compound angle DAE′ is double of DAD′, which would complete two right angles; whence DAE′ is two thirds of two right angles, or one third of a whole circuit.

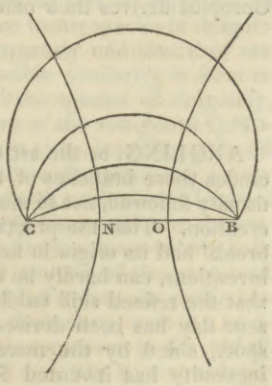
In the *third* position, AE″D″ of the trisecting line, or rather its extension A*e*″, draw CH″ to bisect E″D″. The triangles CH″D″ and ACH″ are then isosceles, and consequently the angle CAD″ or CH″A is double of CD″A; but CAE is likewise double of CEA, and therefore the combined angle D″AE is double of the angles CD″A and CEA. Now this angle D″AE, together with the two angles CD″A and CEA, is evidently equal to the exterior angle DC″E or a right angle. Whence D″AE is two thirds of a right angle, or one third of two right angles, and therefore the adjacent angle DA*e*″ is two thirds of two right angles, or one third of a whole circuit.

3. The simplest and most elegant solution of the trisection of an arc was indicated by Pappus, and is given in Castillon's Commentary on Newton's *Universal Arithmetic*. The problem is there reduced to the combination of the circle with a certain kind of hyperbola. But the general property of the directrix, which belongs to all the conic sections, or the lines of the second order, affords the readiest mode of investigation. Let the arc BD be the third part of BDC. Complete the circle, and draw the chords BD, BC, and CD. The arc CD is evidently double of BD, and therefore the angle CBD is double of BCD. Bisect the angle CBD by the straight line BH, let fall the extended perpendicular, and draw the parallel DK. The triangle CHB is evidently isosceles, and HI bisects the base CB. But the triangle CBD having its vertical angle at B bisected, the side CB is to BD as the segment CH of the base to HD; that is, since the triangles CHI and DHK are similar, as CI to KD; wherefore, CB being the double of CI, BD is likewise double of DK. The ratio of the distances BD and DK is thus given, while the point B is given, and the straight line IH given in position. Whence, from the theory of lines of the Second Order, the locus of the point of section D is an *hyperbola*, of which B is a focus, and IH a directrix, with the determining ratio of two to one. Let this construction be made, and the arc CDB is trisected in D. For since BD is, from the property of the curve, double of DK, it is evident that BC is to CI as BD to DK; and the triangles CIH and KDH being similar, and CI to CH as DK to DH, it follows that BC is to CH as BD to DH, or alternately BC is to BD as CH to DH. Wherefore the vertical angle CBD is bisected by BH, or the angle CBD is double of CBH or of BCD, and consequently the arc CD is double of BD, or BD itself is the third part of the whole arc CDB.



But the opposite branch of the hyperbola, which passes through C, also comes into play; and the intersection of these two branches with the circle assigns three different positions of the point D, separated from each other by intervals equal to the third of the whole circumference. Thus, in the *second* position D′, produce the perpendicular D′K′ to the opposite circumference L; and since BD′ is double of D′K, it must be equal to the chord D′L, and consequently the arc BDCD′ is equal to LD″MD′. Wherefore the double of BDCD′, together with the interval BL or CD′, is equal to the whole circumference; that is, the double of DCD′, with the double of BD and CD′, is equal to the whole circumference; and since the double of BD is DC, the triple of the arc DCD′ must complete the circumference. In the *third* position D″, produce the perpendicular D″K″ as before: the double of this, or the chord MD″, is hence equal to D″B, and the arc BLD″ equal to DM: consequently the double of BLD″, with the compound arc BDCM, completes the circumference; but D″M being parallel to BC, the arc BLD″ is equal to CD′M, and therefore three times the arc BLD″, with the arc BDC, or the triple of BD, will fill up the circumference, or the arc DBD″ is a third part of it.[1]

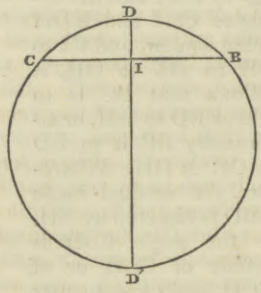
The trisection of innumerable arcs described on the same chord is rendered very conspicuous by combining the separate branches of two hyperbolas that have the determining ratio of two to one, and their foci situate in the extremities of the given line. Thus, let the chord BC be trisected at the points N and O, and from B and C, as distinct foci, and in the determining ratio of two to one, describe branches of independent hyperbolas. All the arcs erected on BC are each of them divided by those curves into three equal portions. These arcs, as they flatten, approach to the trisected chord CNOB on the



[1] For more illustration of this subject, see Leslie's *Geometry of Curve Lines*.

one hand; and as they become enlarged, they constantly tend, on the other, to the complete circumference which the asymptotes of the hyperbola, making angles on each side of the axis equal to two thirds of a right angle, would themselves trisect.

It may be observed in general, that the section of an arc or angle admits of as many different answers as the number of divisions proposed. Thus, the quadrisection would give four distinct results, and a quinsection would involve no fewer than five separate products. Nay, the bisection itself of an arc, though within the limits of the most elementary geometry, yet brings out a double result. Thus, the arc CDB is bisected by the perpendicular or diameter DID′, which not only gives BD for the half of that arc, but also BDCD′, or the same half-arc augmented by a semicircumference.



These conclusions agree with the results derived from the general theory of equations. The expression for the sine of a multiple arc is always an equation of corresponding dimensions, which therefore admits of as many distinct roots as the index contains units.

The ancient geometers were only acquainted with the original division of the circumference into two, three, or five equal portions. The only subdivisions were obtained from the differences of those arcs or their continued bisection. But the very ingenious Professor Gauss has discovered a series of more complex regular polygons, which may be inscribed in a circle by elementary geometry. The expression $2^n + 1$, when a prime number, will represent the sides of the figure: for the general equation of a cosine of the section can be decomposed into quadratics of the simplest kind, which can be constructed by the repeated application of circles and straight lines. A polygon of 17 sides is the first that occurs after the pentagon; and then follow the polygons of 257, 65537, &c. (B.)

Angles, an ancient German nation, originally a branch of the Suevi; who, after various migrations, settled in that part of Denmark, and duchy of Sleswick, of which the city of Flensborg is the capital. Here they were known, even in the time of Tacitus, by the name of *Angli*. The origin of this name is variously accounted for. According to Saxo Grammaticus, they were called *Angli*, from one Angulus, son of Humblus king of Denmark. Goropius derives their name from the Saxon word *Angel* or *Engel*, signifying a fish-hook; the Angles, like the other Saxon nations, being greatly addicted to piracy, and on that account being so named by the neighbouring nations; as if, like hooks, they caught all that was in the sea. To this nation the British ambassadors are said to have applied when soliciting succours against the Scots and Picts. The Angles, therefore, came over in greater numbers than any other Saxon nation, and accordingly had the honour of giving the name of *Anglia* to England.

ANGLESEA, or Anglesey, a county in North Wales, comprehending the island of that name. It is divided from the main island of Great Britain by the narrow river, or rather armlet of the sea, called the Straits of Menai. Over this water a most magnificent suspension bridge has been recently completed, which affords a great facility to the intercourse between London and Dublin. The extent of the county is about 271 square miles, or 174,000 acres. The soil is but moderately fertile; but in average years it yields more barley and oats than the consumption requires. The surplus generally finds a vent in Liverpool. A number of horned cattle, sheep, and hogs, are annually sent over the Menai. The most valuable product of the island arises from the mines. The chief of these, the Parys mine, is the most abundant in copper ore of any mine known in the world; and even in the water lodged beneath the bed of ore, quantities of nearly pure copper are obtained by exposing it to iron. A mine of lead, but rich in silver, has been discovered near the same mountain. Quarries of various kinds of marble, and mines of asbestos, are also found on the island. Coal is obtained at Maltreath in considerable quantities. The mines have, however, of late years diminished in productiveness, especially those of copper. The herring fishery is a branch of industry which in some years gives employment to a portion of the inhabitants.

The island has been celebrated in the most remote periods as the seat of the druidical pontiff, and the great nursery of the instructors in that kind of religion or superstition, of which but little has been handed down by any other mode than by tradition, and which is attended with the doubts and uncertainty naturally arising from that mode of communication. See the article Druid.

At present the Welsh language, of the northern dialect, is almost the exclusive language of the peasantry; but in the towns, especially at Holyhead, English is very generally understood. The county contains 5 towns and 67 parishes. The number of inhabitants in 1801 was 35,000; in 1811, 38,300; and in 1821, 46,000. The county returns one member to parliament, and one is also returned by the borough of Beaumaris. The towns, with their population, are, Holyhead, 4071; Amlwch, 5292; Aberfraw, 1204; Beaumaris, 2205. (G.)

ANGLING.

ANGLING, or the art of fishing with rod and line, includes those branches of the piscatorial trade which are usually followed, not so much for profit, as for pleasant recreation. That the practice of "casting angles into the brook" had its origin in necessity, the mother of so many inventions, can hardly be doubted; but it is equally clear that the refined skill exhibited in this pursuit at the present day has been derived from leisure and the love of sport, aided by the more delicate gear which modern ingenuity has invented for the deception of the finny race.

The comparative merits of angling, and of the kindred occupations of the fowler and the huntsman, are not likely to be determined by any portraiture which a lover of these exciting amusements might draw of their various excellencies, but must depend on the tone and temper of mind possessed by different persons, and their greater or less accordance with individual tastes. This much, however, may be safely stated as a general and admitted truth, that the value of a pursuit increases in proportion as it becomes attainable by the mass of our fellow-creatures; and as angling is a much cheaper and more convenient pleasure than either hunting or shooting, it may, in so far as regards those advantages, claim a decided preference. Be it remembered that Dr Johnson's description of a rod with a fly at one end and a fool at the other

s not admitted among the memorabilia of the lovers of ld Izaak Walton.

The recreation of angling has been followed by many f the best and wisest of men in modern ages. Sir Henry Wotton found from experience, that after prolonged study r worldly occupation, it was "a rest to his mind, a cheer- r of his spirits, a diverter of sadness, a calmer of un- quiet thoughts, a moderator of passions, a procurer of contentedness;" and, besides the immediate excitement f the sport itself, few occupations yield so much plea- ure to the lovers of rural scenery and the admirers of he picturesque. The most beautiful scenes in nature isually adorn or consist of the banks of lakes and rivers; nd the composition of a perfect landscape, whether in na- ure or art, is incomplete without the accessory of either ranquil or flowing waters. The pursuits of the artist nd the angler are therefore peculiarly compatible, and ach lends an interest to the other.

The lofty woods, the forests wide and long,
Adorn'd with leaves and branches fresh and green,
In whose cool bowers the birds with many a song
Do welcome with their quire the summer's queen;
The meadows fair, where Flora's gifts among
Are intermixed with verdant grass between;
The silver scaled fish that softly swim
Within the sweet brook's crystal watery stream:

All these, and many more of His creation,
That made the heavens, the angler oft doth see;
Taking therein no little delectation,
To think how strange, how wonderful they be;
Framing thereof an inward contemplation,
To set his heart from other fancies free;
And whilst he looks on these with joyful eye,
His mind is rapt above the starry sky.

Markham, in his *Country Contentments*, describes not only he outward apparel, but the inward qualities, of an angler. He must be generally accomplished in all the liberal ciences, and, as a grammarian, ought to be qualified to vrite and discourse of his art in true and fitting terms. He must be possessed of *sweetness of speech* to entice thers to so laudable an exercise, and of strength of ar- gument to defend it against envy and slander. "Then nust he be strong and valiant, neither to be amazed with torms, nor affrighted with thunder; and if he is not tem- perate, but has a gnawing stomach that will not endure nuch fasting, but must observe hours, it troubleth the nind and body, and loseth that delight which only mak- th pastime pleasing." "He must be of a well-settled nd constant belief, to enjoy the benefit of his expecta- ion; for then to despair, it were better never to be put n practice: and he must ever think when the waters are leasant, and any thing likely, that there the Creator of ll good things hath stored up much of plenty; and hough your satisfaction be not as ready as your wishes, et you must hope still, that with perseverance you shall cap the fulness of your harvest with contentment. Then e must be full of love both to his pleasure and his neigh- our—to his pleasure, which otherwise will be irksome nd tedious—and to his neighbour, that he never give of- ence in any particular, nor be guilty of any general de- truction: then he must be exceeding patient, and neither ex nor excruciate himself with losses or mischances, as n losing the prey when it is almost in the hand, or by reaking his tools by ignorance or negligence; but with leased sufferance amend errors, and think mischances nstructions to better carefulness."

In regard to the antiquity of angling, it has been traced y some to the time of Seth, who is asserted to have aught it to his sons; and so highly have others esteemed he knowledge of the art, as to maintain that its rules and naxims were engraven on those pillars by which an acquaintance with music, the mathematics, and other branches of useful knowledge, was preserved by God's appointment from extinction in the days of Noah. It is frequently alluded to in the holy Scriptures; as in Isaiah, xix. 8, "The fishers also shall mourn, and all they that cast angle into the brooks shall lament, and they that spread nets upon the waters shall languish;" so in the prophet Habbakuk, i. 15, "They take up all of them with the angle, they catch them in their net, and gather them in their drag; therefore they rejoice and are glad." We deem it unnecessary to multiply quotations from ancient authors, whether sacred or profane; but shall rest satisfied with pointing out, at the close of this article, the principal works on angling which have appeared in our own language, and in relation to the practice of the art in British streams.

As expert angling never was and never will be successfully taught by rule, but is almost entirely the result of assiduous and long-continued practice, we purpose being very brief in our disquisition on the subject. We shall commence by stating our belief that fly-fishing, by far the most elegant and interesting branch of the art, ought not to be regarded exclusively as an art of imitation. It no doubt depends on deception, which usually proceeds on the principle of one thing being successfully substituted in the likeness of another; but Bacon's distinctive definitions of simulation and dissimulation place the subject in a truer light. As simulation consists in the adoption or affectation of what is not, while dissimulation consists in the careful concealment of what really is—the one being a positive, the other rather a negative act—so the great object of the fly-fisher is to dissimulate in such a manner as to prevent his expected prey from detecting the artificial nature of his lure, without troubling himself by a vain effort to simulate or assume, with his fly, the appearance of any individual or specific form of insect life. There is, in truth, little or no connection between the art of angling and the science of entomology; and therefore the success of the angler, in by far the greater proportion of cases, does not depend on the resemblance which subsists between his artificial fly and the natural insect. This statement is no doubt greatly at variance, as well with the principles as the practice of all who have deemed fishing worthy of consideration, from the days of Isaiah and Theocritus, to those of Carrol and Bainbridge. But we are not the less decidedly of opinion, that in nine instances out of ten a fish seizes upon an artificial fly as upon an insect or moving creature *sui generis*, and not on account of its exact and successful resemblance to any accustomed and familiar object.

It may be asked, upon what principle of imitative art the different varieties of salmon-fly can be supposed to bear the most distant resemblance to any species of dragonfly, to imitate which we are frequently told that they are intended? Certainly no perceptible similarity in form or aspect exists between them, all the species of dragonfly, with the exception of one or two of the sub-genus Calepterix, being characterized by very clear, lace-like, pellucid wings, entirely unadorned by those fantastic and gaudy colours, borrowed from the peacock and other "birds of gayest plume," which are made to distinguish the supposed resemblance. Besides, the finest salmon-fishing is in mild weather during the colder seasons of the year, and in early spring, several months before any dragonfly has become visible on the face of the waters, as it is a summer insect, and rarely makes its appearance in the perfect state till the month of June. If they bear no resemblance to each other in form or colour, how much more unlike must they be, when, instead of being swept down the current, as a real one would be, the artificial fly is seen cross-

ing and recrossing every stream and torrent, with the agility of an otter, and the strength of an alligator? Now, as it is demonstrable that the artificial fly generally used for salmon bears no resemblance, except in size, to any living one; that the only tribe which, from their respective dimensions, it may be supposed to represent, does not exist in the winged state during the period when the imitation is most generally and most successfully practised; and if they did, that their habits and natural powers totally disenable them from being at any time seen under such circumstances as would give a colour to the supposition of the one being ever mistaken for the other; may we not fairly conclude that, in this instance at least, the fish proceed upon other grounds, and are deceived by an appearance of life and motion, rather than by a specific resemblance to any thing which they had previously been in the habit of capturing? What natural insect do the large flies, at which sea-trout rise so readily, resemble? These, as well as gilse and salmon, frequently take the lure far within the bounds of the salt-water mark; and yet naturalists know that no such thing as a salt-water fly exists, or at least has ever been discovered by their researches. Indeed no true insect inhabits the sea. What species are imitated by the palmer, or by three fourths of the dressed flies in common use? An artificial fly can, at the best, be considered only as the representation of a natural one which has been drowned, as it is impossible to imitate the dancing or hovering flight of the real insect over the surface of the stream; and, even with that restricted idea of its resemblance to nature, the likeness must be scarcely perceptible, owing to the difference of motion, and the great variety of directions in which the angler drags his flies, according to the nature and special localities of the current, and the prevailing direction of the wind.

The same observations apply, with almost equally few exceptions, to bait-fishing. The minnow is fastened upon swivels, which cause it to revolve upon its axis with such rapidity, that it loses every vestige of its original appearance; and in angling with the par tail, one of the most killing lures for large trout, the bait consists of the nether half of a small fish, mangled and mis-shapen, and in every point of view divested of its natural form.

Fly-fishing has been compared, though by a somewhat circuitous mode of reasoning, to sculpture. It proceeds upon a few simple principles, and the theory is easily acquired, although it may require long and severe labour to become a great master in the art. Yet it is needless to encompass it with difficulties which have no existence in reality, or to render a subject intricate and confused, which is in itself so plain and unencumbered. In truth, the ideas which at present prevail on the matter degrade it beneath its real dignity and importance. When Plato, speaking of painting, says that it is merely an art of imitation, and that our pleasure arises from the truth and accuracy of the likeness, he is surely wrong; for if it were so, where would be the superiority of the Roman and Bolognese over the Dutch and Flemish schools? So also in regard to fishing: The accomplished angler does not condescend to imitate specifically, and in a servile manner, the detail of things; he attends, or ought to attend, only to the great and invariable ideas which are inherent in universal nature. He throws his fly lightly and with elegance on the surface of the glittering waters, because he knows that an insect with outspread gawzy wings would so fall; but he does not imitate (or if he does so, his practice proceeds upon an erroneous principle), either in the air or on his favourite element, the flight or the motion of a particular species, because he also knows that trouts are much less conversant in entomology than M. Latreille, and that their omnivorous propensities induce them, when inclined for food, to rise with equal eagerness at every minute thing which creepeth upon the earth or swimmeth in the waters. On this fact he generalizes,—and this is the philosophy of fishing.

We are therefore of opinion that all, or a great proportion, of what has been so often and sometimes so well said about the great variety of flies necessary to an angler, —about the necessity of changing his tackle according to each particular month throughout the season,—about one fly being adapted solely to the morning, another to noonday, and a third to the evening,—and about every river having its own particular flies, &c. is, if not erroneous, at least exaggerated and misconceived. That determinate relations exist between flies of a certain colour and particular conditions of a river, is, we doubt not, true; but these are rather connected with angling as an artificial science, and have but little to do with any analogous relations in nature. The great object, by whatever means it is to be accomplished, is to render the fly deceptive; and this, in fact, we believe to be more frequently effected when fishing with flies which differ in colour and general appearance from those which are upon the water. When a particular fly prevails upon a river, an artificial one in imitation of it will never resemble it so closely as to appear the same to those below (*i. e.* the fish): on the contrary, a certain degree of resemblance, without any thing like an exact similitude, will only render the finny tribe the more cautious through suspicion; while a different shape and colour, by exciting no minute or invidious comparisons, would probably have been swallowed without examination. Indeed, it seems sufficiently plain, that where means of comparison are allowed, and where exact imitation is at the same time impossible, it is much better to have recourse to a general idea, than to an awkward and bungling individual representation. How often has it been asserted, with all the gravity of sententious wisdom, that the true mode of proceeding in fly-fishing is to busk your hook by the river-side, after beating the shrubs to see what colour of insect prevails. A very expert angler, who perhaps carried the opposite theory rather too far (although he always filled his pannier), was in the habit of stirring the briars and willows to ascertain what manner of fly was not there, and with that he tempted the fishes.

It is admitted, that during mid-summer, when the weather is calm, the sky clear, and the river low, and when what is called fine fishing is necessary, a close imitation both of the appearance and motions of the natural fly may frequently be tried with advantage; in which case the tackle may be allowed to drop gently down the stream: but it more usually happens, from the style of fishing practised during the vernal and autumnal states of a river, that the hook is not deceptive from its appearing like a winged fly which has fallen from its native element, but from its motion and aspect resembling that of some aquatic insect. When the end of the line first falls on the surface of the water, the fish may be deceived by the idea of a natural fly; and it is on that account that the angler should throw his tackle lightly and with accuracy, and it is on that account also that we would advise the more frequent throwing of the line: but so soon as the practitioner begins to describe his semicircle across the river, the character of the lure is changed, and the trout then seizes the bait, not as a drowning insect, but as a creature inhabiting its own element, which had ventured too far from the protection of the shallow shore or the sedgy bank. That this is the case, a subsidiary argument may also be drawn from the fact, that in most rivers the greater number and the finest fish are generally killed by

he drag-fly, which, during the process of angling, swims n inch or two under water.

Nevertheless, as these opinions of ours may not accord vith the practice of other anglers, we shall proceed somewhat more methodically to explain a few of the principles f the art as usually received and followed.

The great secret in fly-fishing, after a person has acquired the art of throwing a long and a light line, is perseverance,—that is, constant and continuous exertion. Fish re whimsical creatures, even when the angler, with all ppliances and means to boot, is placed apparently under he most favourable circumstances. Let him, however, ommence his operations with flies which, upon general rinciples, he knows to be good,—for example, a water-nouse body and dark wing, hare-ear and moorfowl wing, ed hackle and teal or mallard wing. It may frequently appen that for an hour, or even two hours, he will kill othing; but then it will as often happen that for another ouple of hours he will pull them ashore with a most leasing celerity.

Awake but one, and, lo, what myriads rise!

Next comes a pause of another hour or more, during vhich little or nothing is obtained, so that if the intermediate period is frittered away, success is doubtful or mpossible. We believe that the appetites and motions f the finny tribes are regulated and directed by certain to us) almost imperceptible changes in the state of the tmosphere, with which, as they do not proceed from any leterminate or ascertained principles of meteorological cience, it is not easy for the angler to become acquaint-d; and therefore the only method to remedy the *désagrément* thus arising, is to fish without ceasing as long s he remains by the "pure element of waters." The rt of angling, if worthily followed, and with an observant ye, will probably one day or other be the means of hrowing considerable light on the science of electricity, t present one of the most obscure, though at the same ime the most important and influential, of all the subjects f physical learning.

The best *natural* flies, either to use fresh, or to serve s models for the artificial kinds, are, *first*, the different orts of stoneflies (*Phryganea* and *Limnephilus*), which re usually found by the water-side. Their common coours are various shades of brown; they have pretty long eelers or antennæ, which, in a state of repose, are bent ver their shoulders and along their sides; their wings re held decumbent, or close to the sides. They fly eavily, and are produced from aquatic larvæ called caddis r case-worms, remarkable for their curious dwelling-places, which are hollow tubes composed of sand, small hells, and pieces of wood, agglutinated together, and nade heavier or lighter, according to circumstances, that hey may the more easily sink or swim. They are open t either end, and the worm crawls along the stones and gravel, by protruding its legs at the anterior extremity. They disencumber themselves from their aquatic habitations, and assume the winged state in spring and the earlier part of summer. *Secondly*, The different kinds of May flies (*Ephemeræ*), called green drakes, &c. are also produced from larvæ, which, for a long time previous to their appearance as perfect insects, have inhabited the waters. There are many species of this genus, all of which are greedily sought for by trout. They are easily known by their tapering abdomens, veined wings, short antennæ, and the long slender setæ or hairs which terminate their bodies. They chiefly abound from May to mid-summer. *Thirdly*, The small black or ant-fly, is the winged female of the common black ant, and occurs in the nests or hills of that insect during the summer and autumnal months.

There is scarcely any season of the year, excepting the winter months, in which an experienced angler may not successfully ply his trade.[1] In the mid-summer season, when the pools are very clear and shallow, and the streams almost dried up, little can be done without a stirring breeze; so also after a heavy summer flood, immediately ensuing a continuance of dry weather, when the mountain torrents are a sheet of dingy foam, and the crystal depths of the river are converted for a time into an opaque flow of muddy water, the fly-fisher's occupation's gone. But when the turmoil ceases, and the soft south wind begins to disperse or break in upon the dense array of clouds, so as to chequer the streams, and rocks, and "pastoral melancholy" of the green mountains with the enlivening beams of the returning sun, with what pleasure does the angler approach the banks of a favourite and accustomed river! How various and delightful are his sensations! Custom cannot stale their infinite variety:—on the contrary, the longer and more assiduously the pleasure is pursued, the greater the immediate enjoyment, and the more extended the train of agreeable remembrances for after-days. How exciting the first cast into a breeze-ruffled pool, when the unwetted gut still lies in rebellious and unyielding circles on the surface, and yet almost at the same moment the sounding reel gives notice that these circles have been instantaneously stretched into a straight and tightened line! Then comes the long and continuous vibration of rod and reel, indicating the secure hooking of a goodly fish; or that sullen and pulse-like tug, by which a still goodlier one, when hooked in a deep pool, frequently manifests a desire to *dig* its way to the bottom; or that more interrupted music which results from the fantastic leaps of some whimsical individual, which skims and flounders on the top of the water like a juvenile wild-duck.

The ordinary rules for fly-fishing are, to be most assiduous when the streams are somewhat disturbed and increased by rain,—when the day is cloudy, and the waters moved by a gentle breeze, especially from the south. If the river contains long placid pools, then a steady stirring breeze is very desirable, as angling in such situations resembles lake-fishing, where nothing can be achieved upon a glassy surface. If the wind is low and the weather clear, of course the best angling is in the swiftest streams, and in those curling and perturbed eddies which head the smoother depths. In fishing the smoother pools of no great depth, be careful that the shadows of neither rod nor angler come upon the surface; but if a person is skilful in other respects, he need not fear his own shadow in a broad river, but wade boldly down the centre of the stream, fishing its various depths and currents before him and on either side. In clear rivers the flies should be small and rather slender-winged; but when the waters are muddy or increased by rain, a larger lure may be

[1] Although Izaak Walton, that "great master in the art of angling," informs us that no man should in honesty catch a trout till the middle of March, yet the grayling is in best condition during the winter season. "I do assure you," says Charles Cotton, in the second part of the Complete Angler, "which I remember by a very remarkable token, I did once take, upon the sixth day of December, one, and only one, of the biggest graylings, and the best in season, that ever I yet saw or tasted; and do usually take trouts too, and with a fly, not only before the middle of this month, but, almost every year, in February, unless it be a very ill spring indeed; and have sometimes in January, so early as new-year's tide, and in frost and snow, taken grayling in a warm sun-shine day for an hour or two about noon; and to fish for him with a grub it is then the best time of all."

Angling.

made use of. When the streams are brown with rain, an orange-coloured fly is good; in very clear weather a light-coloured one; and a dark fly is advisable for troubled waters.

Though a great deal no doubt depends on a quick eye and an active and delicate hand, we are no great advocates for what is called *striking* a fish. If a large trout rises in a deep pool, it may be of advantage so to do; and this will be sufficiently accomplished by inclining the rod quickly aside, so as to draw out a few inches of the line; for if the reel is not allowed to run, this operation is apt to snap the gut, or otherwise injure the tackle. But if a trout, whether great or small, rises in a current or rapid stream, the sudden change in its position, immediately after it has seized the fly, is generally quite sufficient to fix the barb, without any exertion on the part of the angler.

A variable state of the atmosphere is bad for angling; but neither is a uniformly dull gloomy day the most favourable. It is scarcely possible to lay down any general rules on this branch of the subject. We have half filled a pannier during an electric hail-storm, when "sky lowered and muttered thunder," and the aspect of the day was such as to deter more experienced though less zealous sportsmen from leaving the shelter of their homes. If the river is not too low, we always prefer what in ordinary language might be called a fine cheerful day, more particularly if there is a fresh breeze. And what we would more particularly press upon the notice of the angler, as soon as he becomes master of the line, is, that he should cast his flies more frequently than is the usual practice, and, generally speaking, fish rapidly. This should be more especially attended to in streams where the trout are numerous and not large.

Before enumerating and describing the different kinds of artificial flies in greatest repute, we shall mention a few of the principal materials used by the fly-fisher. The articles which he employs in common with those who prosecute the other branches of the trade, are of course rods, hair and gut lines, reels and hooks, panniers and landing-nets; but in addition to these he must be provided with a great variety of feathers, such as the slender plumes called hackles, from the necks and backs of common poultry, and the wings of a considerable number of birds, such as woodcocks, snipes, rails, plovers, ducks, grouse, partridges, and others. The furs of quadrupeds are also indispensable; and of these the most useful are hares, squirrels, moles, martens, mice, and water-rats.

The most esteemed hackles are the *duns*. The red, striped down the centre with black, and the red with a blackish root, are likewise useful, and more easily obtained. Since the introduction of Spanish poultry (by which name are designated the black breed with white tops), black hackles are now more common than formerly. The proper time for plucking hackles is about Christmas. The feathers of the ostrich and peacock are of frequent service; and for salmon and sea-trout the gaudy plumes of parrots and other brilliantly attired foreign species, however unlike the generality of our northern insects, ought to be collected by every fly-fisher.

The silks commonly used by the angler are of three kinds:—1*st*, Barbers' silk, used double, for splicing the top-pieces of rods; 2*dly*, a more delicate kind, for fastening on the rings through which the reel-line runs; 3*dly*, fine netting silk for whipping hooks and dressing flies. When we mention a pair of small pliers, fine-pointed scissors, needles, and wax, we have noted the principal materials for the angler's trade.

In regard to rods, their length and formation are so much matters of individual taste, that few general rules can be laid down upon the subject. According to Daniel, the wood should be cut about Christmas, and allowed to season for a twelvemonth. Hazel is very generally used, especially that from the *cob-nut*, which grows to a great length, and is for the most part very straight and taper. The but-end should rather exceed an inch in diameter, and the shoots for stocks, middle pieces, and tops, should be as free from knots as possible. The tops are made from the best rush ground shoots. All these pieces should be kept free from moisture till the ensuing autumn, when such as are required to form a rod are selected; and, after being warmed over a gentle fire, they are set as straight as possible, and laid aside for several days. They are then rubbed over, by means of a piece of flannel, with linseed oil, which produces a polish, and brings off the superfluous bark: they are then bound tight to a straight pole, and kept till next spring, by which time they will be seasoned for use. They are then matched together in due proportions, in two, three, or more parts, according to the desired length, or the opinion of the maker as to the number of pieces of which a rod should be composed. A well-constructed spliced rod of no more than two pieces casts a line with fully as much force, neatness, and accuracy as any other; but it is inconvenient to a traveller, or to any one whose dwelling is not close upon a stream. If the pieces are not ferruled, they must be spliced so as to join each other with great exactness. The principal object to be kept in view in the formation of rods in general is, that they should taper gradually and bend regularly. A frequent defect is their bending too much in the middle, owing to that part not being sufficiently strong.

We have said that the length of a rod is rather a matter of taste than of established rule. It must, however, bear a relation to the size of the river and the nature of the expected capture. A trouting rod is usually made from 12 to 14 feet in length, though some prefer them of greater extent, as giving more command over lakes and spreading pools. It should be made as light as is consistent with strength and durability, as a heavy rod is cumbersome, fatiguing, and unwieldy; and a light one gives a more ready power in casting under hollow banks, or among trees or bushes. For pike and barbel a proper length is 16 feet; for perch, chub, bream, carp, eels, and tench, a shorter rod may be used; and 8 or 10 feet is sufficient for dace, gudgeon, ruff, bleak, &c. The portability of a rod depends of course on the number of joints; but its excellence being almost in the inverse ratio, care must be taken not to sacrifice its goodness merely for the sake of a convenient form.

According to Mr Bainbridge, the best rods are made from ash, hickery, and lance-wood; ash for the bottom piece, hickery for the middle, and lance-wood for the top-joints. If real bamboo can be procured of good quality, it is preferable to lance-wood. Rose-wood and partridge-wood from the Brazils may also be used for the top-pieces. The extreme length of the top-piece is usually composed of a few inches of whalebone. The rings for the reel-line may be made by twisting a piece of soft brass-wire round a tobacco-pipe, and soldering the ends together. They ought to diminish in size as they are made to approach the top, and must form a straight and regular line with each other when the rod is put up for use.

In finishing a rod the usual varnish is copal varnish, or Indian rubber dissolved over a slow fire in linseed oil. It may be stained by a dilution of nitric acid or oil of vitriol. When rods are stored for the winter, after use, they ought to be rubbed over with tallow or salad oil. As few anglers require to make their own rods, we deem it unnecessary to enter into a full detail of a mechanical practice which can only be sufficiently executed by an individual of pro-

fessional experience. We shall merely mention, that, in addition to the woods already named, elder, holly, yew, mountain ash, and briar, all of which are indigenous to this country, furnish materials to the makers of rods.

As lines may be purchased from the tackle-makers at a cheaper rate than they can be made by an amateur whose time and labour are of value for any other purpose, we shall not here enter into a detail of their formation. The best hair is procured from the tail of a well-grown stallion. Black hair is generally strong, but the colour is not very serviceable. Transparent and almost colourless hair is the most approved; and it ought to be round, regular, and free from blemishes. In the formation of lines each hair in a link should be equal, round, and even, which proportions the strength and prevents single hairs from breaking, and thus weakening the others. Chesnut or brown-coloured hairs are best for ground angling, especially in muddy water. Some anglers stain their lines a pale green for fishing in weedy waters. Black is occasionally used in streams which flow from mosses, and are themselves of an unusually dingy hue.

The following are some of the methods used by anglers for dyeing their lines, whether of hair or gut.

For a pale watery green.—To a pint of strong ale add half a pound of soot, a small quantity of walnut leaves, and a little powdered alum; boil these materials for half or three quarters of an hour, and when the mixture is cold steep the gut or hair in it for ten or twelve hours.

For a brown.—Boil some powdered alum till it is dissolved; add a pound of walnut-tree bark from the branches when the sap is in them, or from the buds, or the unripe fruit. Let the liquid stand till nearly cool, and skim it; then put in the gut or hair, and stir it round for about a minute, or till it appears to have imbibed the desired tint. It ought not to be strongly tinctured, as it is apt to rot when too dark. For a *bluish watery tint* the above ingredients are also used, with the substitution of logwood instead of walnut.

For a yellow.—The inner bark of a crab-tree boiled in water, with some alum, makes a good yellow, excellent for staining tackle used among decayed weeds, the colour of which it closely resembles.

A tawny hue is obtained by steeping hair among lime and water for four or five hours, and then allowing it to soak for a day in a tan-pit. In the absence of other ingredients, both gut and hair may be easily stained by being left for twenty-four hours in strong tea, either with or without a few log-wood scrapings.

The hair to be dyed ought to be selected from the best white. Silken or hempen lines may be tinted by a decoction of oak bark, which is said to add to the durability of these materials.

We shall now proceed to consider the subject in relation to the different species of fish which form the principal objects of the angler's art.

The Salmon. (*Salmo Salar.*)

As the natural history, classification, and characteristic distinctions of fishes will be given at length under the article ICHTHYOLOGY in this work, we shall not here enter into any description of either the structure or habits of the class, but confine ourselves for the present almost entirely to such points as are most essential to the practical knowledge of the angler.

This fine fish delights in large and rapid rivers. It bites best from six in the morning till eleven in the forenoon, and from three in the afternoon till sunset. A moderate breeze is of advantage; and the best months are March, April, May, and June. The salmon is justly regarded by the angler as the king of fish; and when we consider that they occasionally measure four feet in length, and weigh upwards of 70 pounds, we may conceive how difficult a capture and how valuable a prize they sometimes prove. The most successful bait, as well as the most agreeable in the usage, is the artificial fly. This is made in imitation both of dragonflies and butterflies of various kinds; but the principles which we have already endeavoured to establish at the commencement of this article make it unnecessary to describe the natural species. Even those who most warmly advocate the necessity of imitating existing insects in the formation of their lures, admit that the salmon is so capricious as frequently to rise at an artificial fly which bears no resemblance to any natural form of insect life.

The following are the descriptions of six artificial flies which have been found very successful in raising salmon. No. 1 (see Plate XLV. fig. 1) is recommended as a spring fly, and is composed of the following materials: Wings of the dark mottled brown or blackish feather of a turkey; body of orange camlet mixed with a little mohair; and a dusky red or bright brown cock's hackle, plucked from the back where the fibres are longest, for the legs. The hook should be of the same size as represented in the plate; and it has been observed that all large salmon-flies should be dressed upon two or three lengths of gut twisted together, and that the silk in dressing be brought beyond the shank of the hook, and wrapped four or five times round the gut, so that it may not be speedily cut by the sharpness of the steel.[1] This same fly, dressed with the wings of a somewhat brighter shade, and with the addition of a little gold wire or thread wrapped round the body at equal distances, will also serve for a more advanced season of the year. No. 2 (see Plate XLV. fig. 2) is of smaller size, and may sometimes be dressed upon very strong single gut. Any feather of a coppery or dingy yellow colour, if not too coarse in the fibres, will be suitable for the wings; the body is of lemon-coloured mohair, mixed with a small portion of light brown fur or camlet, with a pale dusky ginger hackle over the whole. The chief object to be attended to in dressing this fly is to produce that uniform hue, devoid of gaudy colouring, from which it has received the name of the *quaker fly.* Of No. 3 (see Plate XLV. fig. 3) the wings are made from the plumes of a cormorant, or from the mottled feathers of a dark mallard: the body is of dark sable, ribbed with gold wire, over which a dusky red hackle is thickly wound: the mottled feathers of a drake are used for the tail; and previous to fastening off, a small portion of flos silk should be unravelled and fastened at the extremity of the hook. This fly, though, like the preceding, of a somewhat sombre cast, is frequently used with success in summer. No. 4 (see Plate XLV. fig. 4) belongs to the gaudy class of lures, "which," says Mr Bainbridge, "however fanciful or varied in shade or materials, will frequently raise fish when all the imitations of nature have proved unsuccessful; indeed so fastidious and whimsical are the salmon at times, that the more brilliant and extravagant the fly, the more certain is the angler of diversion." In this, of course, we perfectly agree. The wings of the fly in question are formed of the extreme end of a Guinea fowl's feather, not stripped, but having the fibres remaining on both sides of the middle stem. A blood-red hackle is fastened on with the wings, and so arranged

[1] Bainbridge's *Fly-Fisher's Guide*, p. 96.

as to extend beyond them: the dyed feathers used by military men will suit, if another showy biped, the scarlet maccaw, is not accessible. The green feather which forms the eye of the peacock's tail should be fastened at the head, and left hanging downwards, so as to cover the body for the space of half an inch; and a few filaments of the same part of the feather may be fastened at the tail. No. 5 has the wings formed from the darkish brown speckled portion of a bittern's wing stripped off from the stem: the head ought to be of the same colours as the body, which is formed of the reddish brown part of a hare's fur, and deep copper-coloured mohair; a bittern's hackle is put over the body for legs, and a forked tail is added, made of a pair of single filaments of the same feather as the wings. Of No. 6 the wings are formed of the mottled feathers of a peacock's wing, intermixed with any fine plain dusky red; the best mixture for the body is the light brown inner hair from a bear's skin, sable fur, and gold-coloured mohair; gold twist, a large black cock's hackle, and a red one a little larger, with a bit of deep red mohair for the head. In addition to these, we might enumerate the brown fly, the blue fly, the king-fisher, the prime dun, the great palmer, the golden pheasant, the gray mallard, and many others; but such as are above described will suffice for the purposes of the present treatise. Fig. 6 of Plate XLV. represents an excellent spring fly; and an approved summer kind is shown on the same plate, fig. 5.

It may be stated at once, that so far from imitating nature, the maker of salmon flies can scarcely form them in too unnatural and extravagant a manner. Let him call in the aid of fancy at all times and places, at least in this country; for the cold and cloudy clime of Scotland assuredly furnishes nothing resembling the lures most frequently and most successfully used. The superabundant use of gold and silver wire ought, however, to be avoided, as it not only causes the fly to sink too much in the water, but prevents its being neatly or lightly thrown. Spring flies for salmon are usually made of a larger size, though not so gaudily dressed as those of summer.

A salmon rod is generally proportioned to the size of the river which the angler frequents; but it ought not to be less than 15 feet in length. The reel ought to be large enough to contain 80 or 90 yards, so as to admit of abundance of line being given out when required; for many fish, when struck, run out to a great distance, and with such immense rapidity as to prevent the possibility of the angler's moving in the proper direction with sufficient quickness. A salmon, for the most part, darts violently up the stream; and, as the command and direction of the fish is more easily kept with a short than a long line, it is advisable to prevent his getting too far ahead, by keeping the rod well back in the opposite direction, and by running towards him along the margin of the stream. When he gains the head of the current, a salmon frequently throws himself several times out of the water, on which occasions the angler must yield him freely a little of the line; but during his general and less violent manœuvring, he will of course be the sooner exhausted the more firmly he is held. When he appears to be making for some safe haunt or secret sheltering place, the great object is to turn him towards safer ground, either by relying on the soundness of the tackle, or, if he proves very powerful as well as very obstinate, then a pebble or two may be thrown, so as to fall a little in advance of his position, and he will probably turn himself round. Some fish become very sulky, and will lie after being hooked, for a long time, motionless near the bottom. In this case also the pebbles must be had recourse to; for the more a fish is kept in motion, the sooner he becomes exhausted. When he begins to show his side, and exhibits other unequivocal symptoms of exhaustion, a favourable landing-place should be looked for; and when the proper time arrives, which can only be learned by the (sometimes dearly bought) lessons of experience, then is he to be drawn by degrees to the gravel bank, or the gaff applied, and the prize secured.

When feeding, salmon are usually found at the foot of a strong stream, terminating in an eddy or whirlpool. "And first," says our father Walton, "you shall observe that usually he stays not long in a place, as trouts will, but, as I said, covets still to go nearer the spring-head; and that he does not, as the trout and many other fish, lie near the water side or bank, or roots of trees, but swims in the deep and broad parts of the water, and usually in the middle, and near the ground; and that there you are to fish for him; and that he is to be caught as the trout is, with a worm, a minnow, which some call a penk, or with a fly."

When the water is either too much discoloured for the use of the artificial fly, or, running into the opposite extreme, becomes (especially in very still weather) too clear and bright, salmon may be successfully angled for with the worm. In this case trolling tackle is sometimes used.

In trolling with minnow or other small fish, the foot lengths ought to be about three yards long, and furnished with one or two swivels, to prevent the line from twisting, as well as to enable the bait to play freely. A lead or shot proportioned to the strength of the stream should be fastened to the line, about a foot above the bait. The top of the rod should be stiffer than that used for fly-fishing; and when the hook is baited, it ought to be thrown first across, and then drawn up the stream.

The salmon fry leave the spawning beds early in spring, and ere long make their way towards the sea. In a few months they again seek their native streams, having, during a very short period, attained to the weight of several pounds. Without entering into the merits of the much-disputed question (still in some points of difficult solution) as to the difference or the identity of samlets, salmon fry, salmon trout, white trout, gilse, and salmon, suffice it to say, that all the migratory kinds of trout, usually characterized by their small number of spots, their silvery colour, and the superiority of their flesh, may be angled for with much larger and more gaudily plumed flies than those used in the capture of river-trout. Flies dressed upon the same principles as those used for salmon, but of smaller size, will be found well adapted for whitings, and the different kinds of sea or migratory trouts above mentioned.

The Common Fresh-water or River Trout. (*Salmo Fario.*)

This species varies greatly in size and colour, in accordance probably with the nature and abundance of its food, the strength and depth of the river in which it occurs, and the physical properties of soil and climate. Fish seem, more than most animals, to depend on peculiar and unappreciable circumstances, for the full and characteristic development of their characters; and they consequently exhibit great contrariety of aspect among individuals of the same species. If a canal or reservoir, or any other great accumulation of water, is formed by the hand of man, where the hand of nature had from time immemorial recognised only some small and solitary streamlet, the lapse of a very few years produces large and heavy fish, where none but trouts of the most trifling size had ever been seen before. The writer of these observations kept a minnow little more than half an inch long in a glass tumbler for a period of two years, during which time there was no perceptible increase in its dimensions.

Had it continued in its native stream, subjected to the attening influence of a continuous flow of water, and a onsequent increase in the quantity and variety of its ood, its cubic dimensions would probably have been 20 imes greater; yet it must have attained, prior to the lapse f a couple of years, to the usual period of the adult state. n regard to birds and quadrupeds, the individuals of the ame species are not distinguishable from each other by ny peculiarities either of form or colour, at least within he limits of a restricted locality; but it appears to be therwise with several species of fish, more especially routs. Those of the Clyde and Tweed, although both ivers draw their primary sources almost from the same ountain, present a constant and well-marked difference n their external aspect; and a corresponding dissimilarity xists among the characteristic varieties of almost every iver and lake in Scotland; "which I tell you that you ay the better believe that I am certain, if I catch a rout in one meadow he shall be white and faint, and very ke to be lousy; and as certainly, if I catch a trout in he next meadow, he shall be strong, and red, and lusty, nd much better meat. Trust me, scholar, I have caught any a trout in a particular meadow, that the very shape nd the enamelled colour of him hath been such as hath oyed me to look on him; and I have then with much leasure concluded with Solomon, 'Every thing is beauiful in his season.'"

No fish affords the angler more varied or more constant port than the trout. For nine months in the year, under avourable circumstances, fly-fishing may be practised for t with success. Westerly and southerly winds are the ost favourable, especially in spring; but during warm nd cloudy summer weather, the point from which the vind blows is of slight consequence. "He who considers he wind," says Solomon, "will never sow;" and the same emark is not inapplicable to angling. Whoever desires o become a successful practitioner in the art, must angle n all weathers, and under every variety of circumstances, owever unpropitious the prospect may be. Trout are generally supposed to rise more freely during a dark and owering day, following a clear bright night, as brilliant noonshine detains them in their lurking-places; and on he ensuing day they are consequently more inclined for ood. On the other hand, after a gloomy or darkish night hey are less easily tempted, having glutted themselves with moths and other nocturnal insects, which, during the summer months, are abundant on the waters. In throwing the line the angler should endeavour to make his gear fall as lightly as possible on the surface, and his flies should drop opposite, or somewhat above his own position, and then be played gently and neatly downwards and across the stream. When a trout is seen to rise at a natural fly or other insect, the artificial one should be offered him by being thrown, not directly over him, but about a yard higher up the stream; and, if he is inclined to rise again, he will probably meet it half-way. When a fish, on being hooked, descends beneath the surface, and struggles in the depths below, it is a pretty sure sign that he is well secured; but when he flounders on the surface, or leaps occasionally into the air, more care is necessary, as in that case the hook will frequently be found to be only skin-deep. In playing and landing a large trout the same precautions are necessary as in salmon-fishing, although in regard to smaller fish, if the angler is standing in the centre of a stream, and finds it inconvenient to wade frequently ashore, a few additional turns will exhaust the capture, which may then be drawn rapidly and steadily to the hand, and secured by a firm grasp behind the gills. We have frequently practised a summary method of landing even tolerably sized fish, which, though it cannot always be effected, is, when possible, a great saving of time. If, from the moment the trout is struck, he is prevented from redescending in such a manner that the upper part of his head and eyes are retained above or on a level with the surface, he will for the space of a good many seconds be so much astonished as to be incapable of any active exertions, and will frequently allow himself to be drawn in that position, and without resistance, straight ashore.

The following flies are in repute among anglers. The *black gnat* appears about the end of April. The body is formed of a black strip from an ostrich feather, and ought to be dressed thick and short; the wings of a pale starling's feather, or dressed as a hackle with a pale dun.

The *March brown* or *dun drake* is frequently visible by the middle of March. The wings are made from the mottled feathers of a partridge's tail, and the body of hare-ear fur, intermixed with a little yellow worsted; a grizzled hackle for legs.

The *hazel fly* is of a round form, and difficult of imitation. It is a killing fly in May and June, especially where bushes abound. The body is composed of ostrich harl of two colours, black and purple twisted together; the wings of the sandy-coloured feathers from under the wings of a thrush, or the reddish plumes of a partridge's tail; a bluish hackle, twisted pretty full, serves both for the under wings and legs.

The *great dark dun*, according to Mr Bainbridge, is one of the earliest flies which appear upon the water, and may be used in February, if the weather is mild. The wings are formed from the dun feathers of a mallard's wing; the body of mole-fur, mixed with a little dark brown mohair; a dark grizzled hackle for legs. Salmon frequently rise at this fly, which may be used with success early in the morning during the whole fishing season.

The *wren's tail* has no wings: the body is of sable fur, with a little gold-coloured mohair, and a feather from the tail of a wren.

The *grouse hackle* is also wingless: the mixture for the body is dark olive, dusky yellow, and a little gold-coloured mohair. It is formed of a fine mottled grouse's feather of a reddish brown, running a little dusky towards the but-end of the stem, and the downy portion, if any, plucked away.

The *stonefly* is found along the edges of streams, and is a favourite article of food among trout. It is a species of Phryganea, and springs from a caddis or aquatic larva. The wings lie flat, and are imitated by the mottled feather of a hen-pheasant or peahen. The body is composed of dark brown fur from a bear's skin, or the deeper part of a hare's ear, mixed with yellow camlet or mohair; a longish grizzled hackle is wrapped under the wings.

The *mealy brown* or *fern fly* is excellent for grayling in May. Its wings should be formed from the under part of a throstle or fieldfare's wing, especially from such feathers as have a yellowish tinge. Its body is of a dusky orange, from the light brown fur of a fox's breast, with a pale dun hackle for legs.

The *orange fly* has four wings made of the blue feather of a mallard-teal. The head is of the dark fur from a hare's ear; the body gold-coloured mohair mixed with orange-camlet and brown fur, a small blue cock's hackle for legs. This is said to be an alluring fly to young salmon.

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[1] Walton's *Complete Angler*, p. 128, edit. 1823.

The *hare's ear* is chiefly used as a drop-fly. The wings are from the light part of a starling's wing feather, and the body of dark hare-ear fur. According to Daniel, when the streams are deep, the same body winged with a rail-wing's feather and a red hackle is very killing during the summer season.

The *yellow dun* is used in the morning and evening during the months of April and May, and again in September. The body is made of yellow yarn unravelled, or with marten's fur, and mixed with a little pale ash-coloured fox-cub fur; the wings are formed upright, from the under part of a snipe's wing, with a pale dun hackle for legs.

The *hawthorn fly* is in use from the middle of April to the end of May, from ten o'clock till three. It has transparent wings, which may be imitated with the palest feather of a snipe or mallard's wing; horn shavings, or the membranous substance found in the core of an apple, serve the same purpose; the body is of black ostrich harl, with a black hackle for legs.

The *summer dun* has a thicker form than most of the dun flies, and is dressed upon a short-shanked hook. Mole-fur ribbed with ash-coloured silk is employed for the body; the wings are from the wood-pigeon, with an ash-coloured hackle for legs.

The *black-hackle fly* is an approved lure during warm weather, early in a summer morning. The body is formed of a thin-dressed ostrich harl, cut close; the wings, four in number, are from the pale feather of the starling's wing.

The *red spinner* is used as a dropper. The wings are formed of the grayish feather of a drake, tinged with reddish yellow; the body a red hackle, with a twist of gold. This fly is eagerly taken by chub in the evenings of July.

The *little yellow May* or *willow fly* resembles the green drake, on a small scale. The body is formed of yellow fur from the marten's neck, or of yellow worsted unravelled, and mixed with a very small portion of hare-ear fur; the wings are of mallard's feather dyed yellow. This fly appears early in May, and may be used till the appearance of the green drake, of which it is the usual precursor.

The *brown dun* is made of otter's fur mixed with lemon-coloured mohair; the wings are from the fieldfare, with a ginger hackle for legs. This is an excellent fly towards the approach of twilight.

The *green drake* or *May fly* appears about the second or third week of May, and continues about a month. The body is made of hog's down, or light bear's hair, intermixed with yellow mohair; or of barbers' yellow silk only, warped with pale flos silk, and a small strip of peacock's harl for the head: a bittern's hackle is the best imitation of the legs and dark stripes of the body; with the long hairs of the sable or polecat for the tail. The rayed feathers of a wild mallard, dyed of a greenish yellow, suffice for wings.

The *blue blow* is a very small fly used during the summer months, and for the first fortnight in August. It is made of a lapwing's top, or any dark blue fur, dressed on a very small hook. The wings are of thistle-down or bluish-white hackle.

The *black midge* is also a small species, the body of which is dressed with brownish-black silk, and a blue cock's hackle. It is taken freely after a shower in the summer evenings.

The *gray drake* follows the green of the same name, although they sometimes occur together. It is an excellent afternoon fly for large trouts. The body is formed of a dirty-white ostrich harl, dressed with flesh-coloured silk, and ribbed with a dark-grizzled cock's hackle; the head is made of peacock's harl, like that of the green drake; the wings from a mottled mallard feather, or that of a mallard-teal, and the tail of sable or polecat's hair.

The *cinnamon fly* has four wings, large in proportion to the body. They are made from the pale reddish-brown feathers of a hen, dressed full; the body of dark brown fur, with a ginger hackle for legs. This fly, according to Mr Bainbridge, is excellent for the Welsh rivers during the months of August and September.

The *sand fly* forms an excellent lure, and may be very generally used from April to September. The wings are formed from the sandy-coloured feathers of the landrail's wing, with a ginger hackle for legs; and the bright sandy-coloured fur from the neck of a hare, mixed with a little orange mohair for the body. If dressed as a hackle, the feathers from under the thrush's wing resemble the natural hue of the wings of the insect.

The *great black ant* makes its appearance in sultry weather, from the middle of June to the latter end of August. The wings are made of the pale-blue feathers from beneath a snipe's wing, or from a tomtit's tail. The body is of black ostrich harl, made thick towards the tail and beneath the but of the wings; the legs of a reddish-brown hackle.

The *great red ant* is nearly contemporaneous with the preceding, which it resembles in size and form. The wings are made of a light starling's feathers; the body of gold-coloured mohair, or copper-coloured peacock's harl, with a ginger hackle for legs.

Among the preceding flies will be found some which will assuredly suit for any river, or for any period of the fishing season. The angler who places implicit confidence in the generally received opinion, that in every stream, and at each season, there is one particular fly in much more special request than any other, will do well to prepare for an unknown river, by making ready a couple of lines, each with three flies all of different kinds. For example, a March brown at the end of the line, a dun hackle, with a lighter or darker body to suit the weather or complexion of the stream, for the first dropper, and a red hackle with peacock body for the second dropper; or, 2*dly*, a sand fly at the end, with a grouse hackle or wren's tail, with orange body, for the first dropper; and a pale yellow or cream-coloured hackle over a bluish body, or one of the ant flies, as the second dropper. These are promising flies for most seasons of the year, though, like the others, they require to be changed according to the circumstances of time and place, or the varying caprices of the finny tribes.

As night fishing is a favourite amusement with many anglers, we shall describe a few of the flies in most repute for the practice of nocturnal sport.

The *white moth*, with wings made from the feathers of a white owl, the body of white ostrich harl, with a white cock's hackle over it.

The *brown moth* is winged from the feathers of a brown owl, or the back feathers of a brown hen; the body is of dark bear's hair, covered with a brown cock's hackle.

The *mealy cream* is made from the tawny feathers of a white owl for the wings, with some soft fur of the same colour, and a pale yellow hackle for the body.

The following selection has been recommended by an experienced angler, in relation to the alleged succession of flies during several of the principal months of the fishing season. 1*st*, For March, a dun fly, made of dun wool, and the feathers of a partridge wing; or the body made of black wool, and the feathers of a black drake: 2*d*, For April, a stonefly, the body made of dark wool, dyed yellow under the wings and tail: 3*d*, For the beginning of May, a ruddy fly, made of red wool, and bound about

ith black silk, with the feathers of a black cock hanging angling on his sides next his tail: *4th*, For June, a green-h fly, the body made of black wool, with a yellow list n either side, the wings taken off the wing of a buzzard, ound with black broken hemp: *5th*, The moorish fly, the ody made of dusky wool, and the wings of the blackish ail of a drake: *6th*, The tawny fly, in great repute till e middle of June; the body made of tawny wool, the ings contrary, one against another, composed of the hitish mail of a white drake: *7th*, For July, the wasp y, the body made of black wool, cast about with yellow lk, and the wings of drakes' feathers: *8th*, The steel fly, proved in the middle of July; the body made with reenish wool, cast about with the feathers of a peacock's il, and the wings made of those of a buzzard: *9th*, For ugust, the drake fly, the body made with black wool ast about with black silk, the wings of the mail of a lack drake, with a black head.

When rivers are very low and clear, from a long conti-uance of summer drought, it has been recommended to se a pair of wings made from the feather of a landrail, r the mottled feather of a teal, with a well-cleaned gen-e fixed upon the hook. During a similar condition of e water, even when no wind is stirring, and the sun ining in its greatest lustre, trouts may be taken with a nall *wren's tail*, *grouse*, *smoky dun*, or *black hackles*, the gler fishing straight down the water, by the sides of reams and banks, and keeping well out of sight, with as ng a line as can be neatly managed, and the foot-lengths ery fine. At these times the fish may be often seen with eir dorsal fins above water, and with skilful manage-ent may be made to snap at the above-named flies. hen one is hooked, the rest dart off; but if the angler eeps concealed, they will return again in a very short me; and thus several fish may be taken even in summer om the clearest pools. Another plan has also been re-ommended as likely to prove successful when the wea-er is bright and the water low: Take a line of about a ard in length, and fix it to a short, stiff rod, and having ited the hook with a natural fly, such as the stonefly, r the gray or green drake (Ephemeræ), drop it between ushes over steep hollow banks, or under the projecting ots of trees.

In fishing a river with which the angler has no previous quaintance, the most approved practice is to try the ddies which are frequent at the corners of streams, and here the circular movement of the current throws out a equent sustenance for the finny race. There the larger out often lie; and it must consist with the experience f every angler, that an excellent capture is sometimes ade repeatedly from some small spot behind or beside a articular stone, where from day to day one well-sized sh seems to succeed another in the favourite feeding round. In this knowledge of peculiar localities consists e chief advantage of a previous acquaintance with the ater. The smaller fish are found in most abundance in e widely spread and shallow streams, as well as in the xtended parts of pools of no great depth. As a general le, the angler may be advised to fish with the wind on is back and the sun in front, which not only gives him greater command of his line, but prevents himself or is shadow from being so distinctly perceived. A strict dherence, however, to this plan is by no means advisable, s the angler's position in relation to sun and wind must equently vary with the natural course of the river, the bstruction of overhanging wood, and the greater or less ommand of pool and stream presented by the varying rm of the adjoining shore.

As *bait-fishing* for trout, though regularly followed by ome, is less generally admired and practised than the more elegant use of the artificial fly, fewer words will suffice. When the streams are swollen and discoloured, fine trout may be taken with a running line without float, and so leaded that it shall touch the ground without resisting the force of the stream. The lead should be fixed about eight or ten inches above the hook; and the best baits are well-scoured earthworms. The dew, the garden, and the lob worms are one and the same in species, although they vary considerably in form, size, and colour, according to age, and season, and the nature of the soils. The lob-worm, according to Daniel, is of two sorts, the old, *knotted*, the young, without knots, which some for distinction call *maiden lobs*, and others *red* worms. The latter kind, with a red head, a streak down the back, and a broad tail, are the most esteemed. By some they are called squirrel-tails. These and other worms, it need scarcely be observed, are easily obtained in fields and gardens, especially where there has been any recent mixture of vegetable or animal remains. They may be preserved for a considerable period, and even improved in their texture and condition, by being kept in damp moss, changed from time to time, and occasionally wetted with a little new milk. In dry weather, when worms are difficult to be obtained, they may be procured by emptying a few buckets of water in situations where they were known to occur during a moister season. The brandling worm is streaked from head to tail in alternate circles of a red and yellow hue, and is darker at its anterior than posterior portion. They occur in old dunghills, in heaps of rich vegetable mould, and among rotten tan bark. They have this advantage over the others, that they may be used without preparation or scouring. Though the choice of worms does not seem a very suitable subject for poetry, it has been thus versified by Mr Gay in the *Rural Sports*:

> You must not every worm promiscuous use,
> Judgment will tell thee proper baits to choose:
> The worm that draws a long immod'rate size,
> The trout abhors, and the rank morsel flies;
> And if too small, the naked fraud's in sight,
> And fear forbids, while hunger does invite.
> Those baits will best reward the fisher's pains,
> Whose polish'd tails a shining yellow stains;
> Cleanse them from filth, to give a tempting gloss
> Cherish the sullied reptile race with moss;
> Amid the verdant bed they twine, they toil,
> And from their bodies wipe their native soil.

The preceding rhymes apply chiefly to the kind called gilt-tails. *Gentles* are the larvæ of different kinds of carnivorous winged flies. They may be kept in a mixture of oatmeal and bran, and are readily produced in a piece of liver, or any other flesh or fish, exposed in an earthen vessel to prevent their escape when grown to a proper size. All kinds of maggots, as well as those called gentles, serve admirably for the more delicate kinds of bait-fishing. The caddis worms, before alluded to as the larvæ of the Phryganea or stonefly, when taken out of their cases, are a favourite bait for trout; and different kinds of grasshoppers are likewise used with great success. The creeper or water cricket, an aquatic larva, found under stones within the water-mark, ought also to be attended to by the natural bait-fisher.

The palmer worms or wool beds are the hairy caterpillars of certain nocturnal moths. Though refused by almost all birds except the cuckoo, they are swallowed by trouts, and may be preserved alive for many weeks in a box with damp earth, strewed over with the leaves of the tree or bush on which the species was observed naturally to feed.

The young brood of wasps and bees are useful to the angler; and for eight or ten days after their first appearance in summer there is no better or more killing bait

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than a small reddish beetle called the *bracken clock* in the north of England, the *Melolontha horticola* of naturalists. Salmon roe is greatly lauded by Barker, who appears to have been the first to discover its merits. "I have found an experience of late which you may angle with, and take great store of this kind of fish. First, it is the best bait for trout that I have seen in all my time, and will take great store, and not fail if they be there. Secondly, it is a special bait for dace or dare, good for chub, or bottlin, or grayling. The bait is a roe of a salmon or trout. If it be a large trout, that the spawns be any thing great, you must angle for the trout with this bait as you angle with the brandling, taking a pair of scissors and cut so much as a large hazel-nut, and bait your hook; so fall to your sport,—there is no doubt of pleasure. If I had known it but twenty years ago, I would have gained a hundred pounds only with that bait: I am bound in duty to divulge it to your honour, and not to carry it to my grave with me. I do desire that men of quality should have it, that delight in that pleasure. The greedy angler will murmur at me, but for that I care not."

Many kinds of pastes are prized by the bait-fisher. They may be used for chub, carp, and bream in September and during all the winter months, and may be made up about the size of a hazel-nut; if for roach and dace, the bigness of a pea will suffice. All pastes are improved by being mixed up in the making with a little cotton wool, which makes them firmer and more tenacious, and hang better on the hook. They suit well for fishing in quiet places, with a small hook and quill float. We shall here subjoin a few recipes for the making of fishing pastes, which, although we introduce them under the head of the river-trout, may be regarded as equally efficacious in the capture of other kinds of fish.[1]

Minnow-fishing for trout is a favourite pastime with many anglers, and the process is one by which very large fish are frequently captured. The tackle used resembles that for salmon, but is lighter and finer, with a single line of gut at the bottom. The hooks vary in size according to the general dimensions of the trout angled for; and the middle-sized and whitest minnows are the most esteemed. The following were Walton's directions for baiting, with a view to this department of the sport. Put your hook in at his mouth and out at his gill; then having drawn your hook two or three inches beyond or through his gill, put it again into his mouth, and the point and beard out at his tail, and then tie the hook and his tail about very neatly with a white thread, which will make it the apter to turn quick in the water: that done, pull back that part of your line which was slack when you did put your hook into the minnow the second time; I say, says Walton, pull that part of your line back so that it shall fasten the head, so that the body of the minnow shall be almost straight on your hook: this done, try how it will turn by drawing it across the water or against a stream; and if it do not turn nimbly, then turn the tail a little to the right or left hand, and try again, till it turn quick. We may add, that the practice of fishing with the artificial minnow is justly discarded by all judicious anglers. For representations of the minnow tackle, and hooks baited, see Plate XLV., fig. 12, 13, and 19.

The Great Lake Trout. (*Salmo Ferox.*)[2]

It appears that the gray or great trout of the British fresh-water lakes, though never described or characterized as a distinct species, has at various times excited the attention of ichthyologists. Trout of enormous dimensions are mentioned by Pennant as occurring in the Welsh lakes; and Donovan gives Loch Neagh in Ireland as another locality. Very large trout have been killed in Ullswater in Cumberland, and still larger in Loch Awe in Argyllshire. The late Mr Morrison of Glasgow claimed the merit of discovering these fish in the last-named locality about 40 years ago; and the largest recorded to have been killed there weighed 25 pounds. Mr Lascelles, a Liverpool gentleman, has also of late years been equally assiduous and successful in their capture; and it appears that any persevering sportsman is almost certain, with the proper tackle, to obtain specimens in Loch Awe, of this great fish, weighing from 10 to 20 pounds. The largest we have lately heard of weighed 19¼ pounds. It is said to be by far the most powerful of our fresh-water fishes, exceeding the salmon in actual strength, though not in activity. The most general size caught by trolling ranges from 3 to 15 pounds: beyond that weight they are of uncommon occurrence. If hooked upon tackle of mode-

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[1] *Red paste* may be made with a large spoonful of fine wheat-flour, moistened with the white of an egg, and worked with the hands until tough. A small quantity of honey or loaf-sugar finely powdered must be added, together with some cotton-wool spread equally over the paste when pressed flat in the hand; it must be well kneaded, to mix the cotton thoroughly; colour it with a little vermilion. A small piece of fresh butter will prevent it from becoming hard, and it will keep good a week. *White paste* may be composed of the same ingredients, omitting the vermilion; and *yellow paste* in like manner, with the addition of turmeric.

Salmon paste.—Take one pound of salmon-spawn in September or October; boil it about 15 minutes, then beat it in a mortar until sufficiently mixed, with an ounce of salt and a quarter of an ounce of saltpetre; carefully pick out the membrane in which the spawn is contained, as it is disengaged from it; when beat to a proper consistence, put it into gallipots, and cover it over with bladders tied down close, and it will keep good for many months.

Various oils were formerly in great repute among anglers for rubbing over their baits, but as we believe their beneficial effects were entirely imaginary, we shall not occupy our pages by their repetition. A single extract from Izaak Walton will suffice. "And now I shall tell you that which may be called a secret: I have been a-fishing with old Oliver Henley, now with God, a noted fisher both for trout and salmon, and have observed that he would usually take three or four worms out of his bag, and put them into a little box in his pocket, where he would usually let them continue half an hour or more before he would bait his hook with them. I have asked him his reason, and he has replied, 'he did but pick the best out, to be in readiness against he baited his hook the next time.' But he has been observed, both by others and myself, to catch more fish than I or any other body that has ever gone a-fishing with him could do, and especially salmons; and I have been told lately, by one of his most intimate and secret friends, that the box in which he put those worms was anointed with a drop, or two or three, of the oil of ivy-berries made by expression or infusion; and told that by the worms remaining in that box an hour, or a like time, they had incorporated a kind of smell, that was irresistibly attractive, enough to force any fish within the smell of them to bite." We need scarcely remind the reader of the "Complete Angler," that that admirable work is of higher value for the manner in which the subject is discussed, and the beautiful accessories of pure style, poetical sentiment, and picturesque illustration, than for the amount of direct practical information which it conveys. The simplicity and goodness of Izaak Walton's nature seem to have induced a greater degree of credulity than was always consistent with an accurate perception of the truth, and hence every chapter abounds with statements which could not pass current in these more critical days. As a useful work in relation to the mere angler, it cannot be said to hold a high rank, although it must ever delight the general reader, and all who desire to refresh themselves by "the pure well of English undefiled."

[2] We are indebted for the principal materials of the following account of this interesting fish to a manuscript of Sir William Jardine's, with which we have been kindly favoured by the author. It forms part of a series of *Memoirs on British Fishes*, which that assiduous naturalist has been for some time past preparing for the press.

rate strength, they afford excellent sport; but the general method of fishing for them is almost as well adapted for catching sharks as trout; the angler being apparently more anxious to have it in his power to state that he had caught a fish of such a size, than to enjoy the pleasure of the sport itself. However, to the credit of both parties, it may be stated, that the very strongest tackle is sometimes snapped in two by its first tremendous springs. The ordinary method of fishing for this king of trouts is with a powerful rod, from a boat rowing at the rate of from three to four miles an hour, the lure a common trout from three to ten inches in length, baited upon six or eight salmon hooks, tied back to back upon strong gimp, assisted by two swivels, and the wheel-line strong whip-cord. Yet all this, in the first impetuous efforts of the fish to regain its liberty, is frequently carried away for ever into the crystal depths of Loch Awe!

When in their highest health and condition, and indeed during the whole of the time in which they are not employed in the operation of spawning, these fish will scarcely ever rise at a fly. At these periods they appear to be almost entirely piscivorous; so, with the exception of light lines, baited also with trout, trolling is the only advisable mode of angling for them. The young, however, rise very freely at ordinary lake-trout flies, and are generally caught in this way from one to one and a half pound weight. They occur abundantly near the outlet of the lake.

About the middle of August, and during the three following months, the parent fish retire, for the purpose of spawning, to the deep banks of the lake in the neighbourhood of the gorge, and into the gorge of the lake itself, where it empties its immense waters, forming the river Awe. They are said to remain engaged in this operation for two or three months, and at this time their instinctive tendencies are so far changed, that they will rise eagerly at large and gaudily dressed salmon-flies, and may be either angled for from the banks, or trolled with a cross line, where the outlet of the lake is narrow. They do not appear either to ascend the rivers which enter the loch, or to descend the Awe to any extent, though an occasional straggler has been taken some way down the river. Their spawning places are exclusively on the banks, or at the gorge of the loch, and they never attempt to seek the salt-water. When in good season, and in their strongest condition, they appear to roam indiscriminately through every part of the loch, though there are certain spots which may be more depended upon than others, and where an experienced angler will have little difficulty in hooking one of these fine fish. To their great strength we may observe that they add unequalled rapacity; and after attaining to the weight of three or four pounds, they appear to feed almost exclusively on smaller fish, and do not spare even their own young. A small trout of this species, not weighing more than $1\frac{1}{2}$ pound, will often dash at a bait not much inferior to itself in size; and instances are recorded of larger fish following with eager eye, and attempting to seize upon others of their own kind after they had been hooked and were in the act of being landed by the angler. It is probably on account of this strong manifestation of a more than usually predaceous habit, that Sir William Jardine has named the species *salmo ferox*.

When in perfect season, and full-grown, it is a very handsome fish, though the head is always too large and long to be in accordance with our ideas of perfect symmetry in a trout. The body is deep and thickly formed, and all the members seem conducive to the exercise of great strength. The colours are deep purplish brown on the upper parts, changing into reddish gray, and thence into fine orange-yellow on the breast and belly. The whole body, when the fish is newly caught, appears as if glazed over with a thin tint of rich lake-colour, which fades away as the fish dies, and so rapidly, that the progressive changes of colour are easily perceived by an attentive eye. The gill-covers are marked with large dark spots; and the whole body is covered with markings of different sizes, and varying in amount in different individuals. In some these markings are few, scattered, and of a large size; in others they are thickly set, and of smaller dimensions. Each spot is surrounded by a paler ring, which sometimes assumes a reddish hue; and the spots become more distant from each other as they descend beneath the lateral line. The lower parts of these fish are spotless. All the fins are broad, muscular, and extremely powerful; and it is from the number of their bony rays that the specific characters which distinguish this species from the common trout (*salmo fario*) are the most easily and accurately evolved. The dorsal fin is of the same colour with the upper part of the fish; it is marked with large dark spots, and contains fifteen rays, which number exceeds by three that which characterizes the common trout. The caudal fin is much larger and more fleshy. The pectoral, ventral, and anal fins, are very muscular on their anterior edges, and of a rich yellowish-green colour, darker towards their extremities. They contain respectively 14, 10, and 12 rays, whereas the numbers in the corresponding fins of the common trout are 13, 9, and 11. The tail is remarkable for its breadth and consequent power. In adults it is perfectly square, or might even be described as slightly rounded at its extremity: in the young it is slightly forked, and appears to fill up gradually as the fish advances in age. In the common trout, on the contrary, the forked shape of the tail is a permanent characteristic.

The flavour of this great lacustrine species is coarse and indifferent. The colour of the flesh is orange-yellow, not the rich salmon-colour of a fine common trout in good season. The stomach is very capacious, and on dissection (differing singularly in this respect from the salmon) is almost always found gorged with fish.

We have bestowed a somewhat lengthened notice on the species above described; but we doubt not that the novelty of the subject will not only plead our excuse, but render the information now given highly acceptable both to the sportsman and the naturalist. It is certain that a more attentive examination of the finny tribes which inhabit our lakes and rivers would bring to light several new species, and more clearly illustrate the history of others which are still involved in obscurity.[1]

The gigantic species of the Swiss lakes, one of which,

[1] Mr Lascelles lately killed two trouts in Loch Laggan, which weighed 12 pounds each. These were probably of the same species with the great trouts of Loch Awe. In that magnificent chain of English lakes of which Windermere is the chief, and which includes Grassmere and Rydal, we think the species not synonymous with the *salmo ferox* of Jardine. The lake trouts, properly so called, of these beautiful waters, when full-grown, seem to range from three to five pounds, and have in one or two rare instances been taken of the weight of six and even eight pounds. Those of Ullswater, again, which does not belong to what we have denominated the Windermere chain, correspond more nearly in size and other characters with the species found in the lakes of the Scotish Highlands. We would particularly recommend to the attention of sportsmen the great fresh-water river trout, or bull trout as we believe it is sometimes called. This is regarded by some anglers as an aged or overgrown individual of the ordinary kind (*salmo fario*); and by others, especially when found in the autumn, as a lake trout which had left its more usual haunts for the purpose of spawning. The accuracy of the latter opinion is, however, interfered with by the occasional occurrence of this variety in such unambiguous situa-

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killed in the lake of Geneva, weighed 67 pounds, are probably identical with those of Loch Awe, Ullswater, &c. Though equal to salmon, both in size and strength, they differ in their habits from those fish, and do not appear at any time to seek the waters of the ocean. Indeed their existence in the lake of Constance, the available communication of which with the sea is cut off by the falls of Schaffhausen, demonstrates their independence of saline waters. It does not appear, from any information which has reached us on the subject, that these great continental lake-trouts ever rise at the artificial fly.

In Loch Ard there is a finely formed and beautiful variety of the common trout, varying in its matured condition from one and a half to three pounds in weight. It affords excellent sport to the angler fishing from a boat about 50 yards off the deeper parts of the shores. They rise freely to small salmon or sea-trout flies, dressed after the model of a gray or green drake.

The rich and varied supply of all kinds of tackle, which may be obtained in the shops of the principal dealers in our larger cities, induces us to abstain from any description of the different hooks employed in minnow and other bait-fishing, as such details are not very intelligible without the aid of numerous engravings. More knowledge will be gained by a few minutes' inspection of the articles themselves in the hands of an intelligent workman, than can be conveyed by the most elaborate treatise on the subject.

Having described the characteristic modes of angling for salmon and trout, the two species which so greatly surpass all the others in the amusement yielded to the angler, we shall now proceed to a briefer consideration of some of the remaining subjects of our sport.

The Char or Case Char. (*Salmo Alpinus.*)
The Torgoch or Red Char. (*Salmo Salvelinus.*)

These fish, which, in a culinary point of view, are deservedly the most highly prized of all the permanently fresh-water species, are scarcely attainable by the angler's skill. Of late years they have risen more freely than in former times in the meres of the north of England; but the capture of a char by rod and line is still regarded as an uncommon occurrence. They appear to retire during the warmer months to the deepest of the still waters, as the fishermen engaged in throwing their nets for pike, perch, and trout, over the very grounds where, during the colder season of the year, the char abound, never catch any of these fish in summer. Although a good deal has been written upon the subject, it does not appear that the distinctive history of the two species above named has been as yet made out. Both the case char and the red char are found in Windermere; and the principal distinction in their habits and history consists in this, that the former ascends the rivers, where it spawns about Michaelmas; whereas the latter deposits its ova along the shores of the lake, and not till the end of December or the beginning of the year. In angling for char the same flies may be used as those best adapted for the smaller-sized lake-trouts; and as the latter occur wherever the former is found, the sportsman has the better chance of making amends for the probable disappointment which will attend his pursuit of the one, by a more successful capture of the other.

The Grayling. (*Salmo Thymallus.*)

This fish loves the clear streams of mountainous countries. It is common in Lapland, where its intestine is used as rennet, along with rein-deer milk, in the formation of cheese. It is a bold and sportive fish, but more tender in the mouth than the trout. It rises well to the camlet fly, and to several of the other small-sized trout-flies. We killed it readily in Switzerland with a moorfowl wing and hare-ear body. They may also be taken with the caddis worm and other ground baits. According to the Rev. Mr Low, the grayling is frequent in the streams of the Orkney Islands, though very rare in the rivers of the mainland of Scotland.

The Pike. (*Esox Lucius.*)

This "fell tyrant of the liquid plain" is not regarded as indigenous to the waters of Britain, but is said to have been introduced in the time of Henry VIII. That it was well known in England at an earlier period is however evident, both from the book of St Alban's, printed by Wynken de Worde in 1496, and from the account of the great feast given by George Nevil, archbishop of York, in the year 1466. There is in truth no evidence either of its non-existence in this country at a remote period, or of its importation during comparatively recent times.

The voracity of this fish is almost unexampled, even in a class remarkable for their omnivorous propensities. Goslings, young ducks, and coots, water-rats, kittens, and the young of its own species, besides every kind of fresh-water fish, have been found in the stomach of the pike. It is said to contend with the otter for its prey, and has been known to pull a mule into the water by the nose. This fish is in season from May to February, and is angled for by trolling with a strong-topped rod. The hooks are generally fastened to a bit of brass wire for a few inches from the shaft, to prevent the line from being snapped. Different methods are used in angling for pike. *Trolling*, in the more limited sense of the word, signifies catching fish with the gorge hook, which is composed of two, or what is called a double eel-hook; *live bait-fishing* is practised with the aid of a floated line; and *snap-fishing* consists in the use of large hooks, so baited as to enable the angler to strike the fish the moment he feels it bite, immediately after which he drags it *nolens volens* ashore.

Trolling for pike may be practised during the winter months, when trout fishing has ceased; and the colder season of the year is in fact more convenient for the sport, owing to the decay or diminution of the weeds which usually surround their favourite haunts. With the exception of chub and dace, which bite pretty freely at the bottom all winter, scarcely any other fish can be relied upon for sport during the more inclement portion of the year. To bait a gorge hook, take a baiting needle, and hook the curved end to the loop of the gimp, to which the hook is tied; see Plate XLV. fig. 20; then introduce the point of the needle into a dead bait's mouth, and bring it out at the middle of the fork of the tail, by which means the piece of lead which covers the shank of the hook, and part of the connecting wire, will lie concealed in the interior of the bait: the shank will be in the inside of its mouth, and the barbs on the outside, turning upwards. See Plate LXV. fig. 24. To keep the bait steady on the hook, fasten the tail part jus

tions as the Clyde above the falls, the waters of which have no communication with any lake. This species sometimes attains th weight of 8, 10, or even 12 pounds; but it differs from the Loch Awe trout in being generally, if not exclusively, found in rivers Those of many of the lesser Highland lakes, such as Loch Ard and Loch Chon, ascend the mountain streams in the autumn to spawn and in the ordinary practice of angling (with the artificial fly) are rarely caught above the weight of three pounds. We last year (1829 received some very singular trouts from a small loch called Lochdow, near Pitmain, in Inverness-shire. Their heads were short an round, and their upper jaws were truncated like that of a bull-dog. They do not occur in any of the neighbouring lochs, and hav not been observed above the weight of half a pound. Trouts of the ordinary shape likewise occur in Lochdow.

above the fork to the gimp, with a silk or cotton thread; or a neater method is, to pass the needle and thread through the side of the bait, about half an inch above the tail, so as to encircle the gimp in the interior. The baits used vary in weight from one to four ounces, and the hooks must be proportioned to the size of the fish with which they are baited. The barbs of the hook ought not to project much beyond the sides of the mouth, because, as the pike generally seizes his prey crosswise, and turns it before it is pouched or swallowed, if he feels the points of the hook he may cast it out entirely.

In trolling for pike, it is advised to keep as far from the water as possible, and to commence casting close by the near shore, with the wind blowing from behind. When the water is clear and the weather bright, some prefer to fish against the wind. "After trying closely," says Mr Salter, "make your next throw further in the water, and draw and sink the baited hook, drawing it straight upwards near to the surface of the water, and also to right and left, searching carefully every foot of water; and draw your bait with the stream, because you must know that jack and pike lay in wait for food with their heads and eyes pointing up the stream, to catch what may be coming down; therefore experienced trollers fish a river or stream down, or obliquely across; but the inconsiderate as frequently troll against the stream, which is improper, because they then draw their baited hook behind either jack or pike when they are stationary, instead of bringing it before his eyes and mouth to tempt him. *Note.*—Be particularly careful, in drawing up or taking the baited hook out of the water, not to do it too hastily, because you will find by experience that the jack and pike strike or seize your bait more frequently when you are drawing it upwards than when it is sinking. And also further observe, that when drawing your bait upwards, if you occasionally shake the rod, it will cause the bait to spin and twist about, which is very likely to attract either jack or pike."[1]

These fish are partial to the bends of rivers and the bays of lakes, where the water is shallow, and abounding in weeds, reeds, water lilies, &c. In fishing with the gorge hook, and the angler feels a run, he ought not to strike for several minutes after the fish has become stationary, lest he pull the bait away before it is fairly pouched. If a pike makes a very short run, then remains stationary for about a minute, and again makes one or two short runs, he is probably merely retiring to some quiet haunt before he swallows the bait; but if, after remaining still for three or four minutes, he begins to shake the line and move about, the inference is that he has pouched the bait, and feels some annoyance from the hook within, then such part of the line as has been slackened may be wound up, and the fish struck. It is an unsafe practice to lay down the rod during the interval between a run and the supposed pouching of the bait, because it not unfrequently happens that a heavy fish, when he first feels the hooks in his interior, will make a sudden and most violent rush up the river or along the lake, and the line is either instantly broken, or is carried, together with both the rod and reel, for ever beyond the angler's reach. "When the pike cometh," says Colonel Venables, "you may see the water move, at least you may feel him; then slack your line and give him length enough to run away to his hould, whither he will go directly, and there pouch it, ever beginning (as you may observe) with the head, swallowing that first. Thus let him lye untill you see the line move in the water, and then you may certainly conclude he hath pouched your bait, and rangeth about for more; then with your trowl wind up your line till you think you have it almost streight, then with a smart jerk hook him, and make your pleasure to your content."[2]

The fresher and cleaner the bait is kept, whether for trolling, live-bait, or snap-fishing, the greater is the chance of success.

As pike, notwithstanding their usual voracity, are sometimes, as the anglers phrase it, more on the play than the feed, they will occasionally seize the bait across the body, and, instead of swallowing it, blow it from them repeatedly and then take no further notice of it. The skilful and wily angler must instantly convert his gorge into a snap, and strike him in the lips or jaws when he next attempts such dangerous amusement. The dead snap may be made either with two or four hooks. (See Plate XLV. fig. 21.) Take about twelve inches of stout gimp, make a loop at one end, at the other tie a hook (size No. 2), and about an inch farther up the gimp tie another hook of the same dimensions; then pass the loop of the gimp into the gill of a dead bait-fish, and out at its mouth, and draw the gimp till the hook at the bottom comes just behind the back fin of the bait, and the point and barb are made to pierce slightly through its skin, which keeps the whole steady: now pass the ring of a drop-bead lead over the loop of the gimp, fix the lead inside the bait's mouth, and sew the mouth up. (See Plate XLV. fig. 22.) This will suffice for the snap with a couple of hooks. If the four-hooked snap is desired (and it is very killing), take a piece of stout gimp about four inches long, and making a loop at one end, tie a couple of hooks of the same size, and in the same manner as those before described. After the first two and the lead are in their places, and previous to the sewing up of the mouth, pass the loop of the shorter gimp through the opposite gill, and out at the mouth of the bait; then draw up the hooks till they occupy a position corresponding to those of the other side: next pass the loop of the longer piece of gimp through that of the shorter, and pull all straight: finally, tie the two pieces of gimp together close to the fish's mouth, and sew the latter up.

Some anglers prefer fishing for pike with a floated line and a live bait. When a single hook is used for this purpose, it is baited in one or other of the two following ways: Either pass the point and barb of the hook through the lips of the bait, towards the side of the mouth, or through beneath the base of the anterior portion of the dorsal fin. (See Plate XLV. fig. 25.) When a double hook is used take a baiting needle, hook its curved end into the loop of the gimp, and pass its point beneath the skin of the bait from behind the gills upwards in a sloping direction, bringing it out behind the extremity of the dorsal fin; then draw the gimp till the bend of the hooks are brought to the place where the needle entered, and attach the loop to the trolling line. (See Plate XLV. fig. 23.) Unless a kind of snap-fishing is intended, the hooks for the above purpose should be of such a size as that neither the points nor the barbs project beyond either the shoulder or the belly of the bait.

Snap-fishing is certainly a less scientific method of angling for pike than that with the gorge or live bait; for when the hooks are baited the angler casts in search, draws, raises, and sinks his bait, until he feels a bite. He then strikes with violence, and drags or throws his victim on shore; for there is little fear of his tackle giving way,

[1] *The Troller's Guide*, by T. F. Salter, Lond. 1820. In the work above quoted will be found a full account of the necessary implements, and the most approved practice, in this department of the art.

[2] *The Experienced Angler*, p. 36. Third edit. Lond. 1668.

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as that used in snap-fishing is of the largest and strongest kind. "This hurried and unsportsman-like way of taking fish," it is observed in the *Troller's Guide*, "can only please those who value the game more than the sport afforded by killing a jack or pike with tackle which gives the fish a chance of escaping, and excites the angler's skill and patience, mixed with a certain pleasing anxiety, and the reward of his hopes. Neither has the snap-fisher so good a chance of success, unless he angles in a pond or piece of water where the jack or pike are very numerous or half starved, and will hazard their lives for almost any thing that comes in their way. But in rivers where they are well fed, worth killing, and rather scarce, the coarse snap-tackle, large hooks, &c. generally alarm them. On the whole, I think it is two to one against the snap in most rivers; and if there are many weeds in the water, the large hooks of the snap, by standing rank, are continually getting foul, damaging the bait, and causing much trouble and loss of time."

Pike sometimes rise at an artificial fly, especially in dark, windy days. The fly ought to be dressed upon a double hook, and composed of very gaudy materials. The head is formed of a little fur, some gold twist, and (if the angler's taste inclines that way, for it is probably a matter of indifference to the fish) two small black or blue beads for eyes. The body is framed rough, full, and round, the wings not parted, but made to stand upright on the back, with some small feathers continued down the back to the end of the tail, so that when finished they may exceed the length of the hook. The whole should be about the bulk of a wren. The largest pike ever killed in Britain was taken with a peacock-feather fly in Loch Ken, near New Galloway. It weighed 72 pounds.[1]

During clear and calm weather in summer and autumn, pike take most freely about three in the afternoon: in winter they may be angled for with equal chances of success during the whole day: early in the morning and late in the evening are the periods best adapted for the spring.

The Carp. (*Cyprinus Carpio.*)

This fish, like the preceding, is asserted to have been introduced into England by Leonard Mascal, a gentleman of Sussex, early in the 16th century; and in good company, if there is truth in the old distich,

> Turkies, carps, hops, pickerell, and beer,
> Came into England all in one year.

The carp is, however, mentioned as a *dayntous fysshe*, though scarce, by Juliana Barnes, in the year 1496. It attains to a prodigious size in the waters of the south of Europe, and in the Lake of Como is said sometimes to weigh 200 pounds. It breeds more freely in ponds than in rivers, although those of the latter are more esteemed. Angling for carp requires, according to Walton, "a very large measure of patience." The haunts of this fish in the winter months are the broadest and least disturbed parts of rivers, where the bottom is soft and muddy; but in summer it usually lies in deep holes, near some *scour*, under roots of trees, and beneath hollow banks, or in the neighbourhood of beds of aquatic weeds. In ponds they thrive best in a rich marl or clayey soil, where they have the benefit of shade from an overhanging grove of trees.

Small carp bite eagerly, but the larger and more experienced fish are deceived with difficulty. The rod should be of good length, the line strong, furnished with a quill float, and ending in a few lengths of the best silk-worm gut. The hook is proportioned to the size of the bait, and a single shot is fixed about 12 inches above it. "Three rods," says Daniel, "may be employed; one with the bait at mid-water, another a foot or less from the bottom, and the third to lie upon it when the line and lead are not discovered, as in the two former; the places intended to be fished in should, the night before, be ground-baited with grains, blood, and broken worms, incorporated together with clay, the hook baits should be red worms taken out of tan, flag or marsh-worms, green peas so boiled as to soften, but not to break the skin, and throwing some in now and then. When this bait is used (which should be with one on the hook to swim a foot from the ground), in case of a bite, strike immediately; a large carp, upon taking the bait, directly steers for the opposite side of the river or pond."[2] During hot weather, when these fish are about to spawn, and whilst lying among the weeds near the surface, they may be angled for with a fine line, without either sink or float. The hook may be baited with a red worm, a pair of gentles, a caterpillar, or a cad bait, and thrown lightly as in fly-fishing, and then drawn towards the angler. If it can be made to fall first upon the leaf of some water plant, and then dropped upon the surface, the chance of success will be increased. The best months are May, June, and July, and the most advisable times of the day are from sunrise to eight in the morning, and from sunset during the continuance of twilight, and onwards through the night. It is the opinion of many, though we cannot trace the origin of the idea, no doubt an erroneous one, that the 10th of April is a fatal day for carp.

The Bream. (*Cyprinus Brama.*)

This fish breeds both in deep, slow-running rivers, and in ponds. It prefers the latter. The most enticing bait is a well-conditioned earthworm, although the angler also uses paste made of bread and honey, wasp grubs, grasshoppers, &c. Boiled wheat serves well for ground-baiting the spot on the preceding nights, and some fasten a number of worms to a piece of turf, and sink it to the bottom. When the ground has been thus prepared, and the tackle put in order, the angler should commence his labours by three or four in the morning. Let him approach the place with caution, so as not to be perceived by the fish, and cast his hook neatly baited with a live and moving worm, in such manner that the lead may lie about the centre of the prepared ground. The bream is a strong fish, and runs smartly when first struck; but after a few turns he falls over on his side, and allows the angler to land him without much trouble. He is by no means so lively as the carp. The best hours for bream are from four till eight in the morning, and from four in the afternoon till eight in the evening. In the river Trent, near Newark, there are two kinds of bream. The common species is that called the carp bream, from its yellow colour; and it sometimes attains the weight of eight pounds. The other species or variety, regarded by Mr Revett Shepherd as a nondescript, never exceeds a pound in weight. It is of a silvery hue, and is known by the name of white bream.[3] The bream, though rare in Scotland, occurs in Loch Maben.

The Tench. (*Cyprinus Tinca.*)

This species is a lover of still waters, and his haunts in rivers are among weeds, or pools well screened by bushes. Tench are found spawning from June till September, and they are in the best condition from the latter month till the end of May. The tackle should be strong, with a swan or goose-quill float for ponds, and a piece of cork for rivers. The hook (in size from No. 4 to 6) should

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[1] Daniel's *Rural Sports*, vol. ii. p. 275.

[2] *Ibid.* p. 257.

[3] *Linn. Trans.* vol. xiv. p. 537.

be whipt to sound silk-worm gut, with two or three shot fixed to it at the distance of a foot. The bait should float about a couple of feet from the surface, and should be drawn occasionally gently upwards, and allowed slowly to sink again. Small marsh worms, middle-sized lobs, or the red species found in rotten tan, are to be recommended. "He will bite," says Walton, "at a paste made of brown bread and honey, or at a marsh-worm, or a lob-worm: he inclines very much to any paste with which tan is mixed, and he will bite also at a smaller worm with his head nipped off, and a sod-worm put on the hook before that worm; and I doubt not but that he will also in the three hot months, for in the nine colder he stirs not much, bite at a flag-worm, or at a green gentle: but can positively say no more of the tench, he being a fish that I have not often angled for; but I wish my honest scholar may, and be ever fortunate when he fishes."

The Barbel. (*Cyprinus Barbus.*)

In a culinary point of view this is one of the worst of the fresh-water fishes. It is gregarious, and roots among the soft banks with its nose, like a sow. The angling season commences in May, and continues till September. The most approved hours are from daylight till ten in the morning, and from four in the afternoon till about sunset. The line should be strong and rather heavily leaded, so that the bait may float about half an inch from the ground. Considerable caution is required in playing this fish, as he is apt to run off when struck, with great violence, towards some stronghold, and in so doing sometimes breaks both rod and line. He is rather nice in his baits, which must be kept clean and sweet, and untainted by musty moss. "One caution," says Mr Daniel, "in angling for barbel, will bear repetition: never throw in the bait farther than enabled by a gentle cast of the rod, letting the plumb fall into the water with the least possible noise. It is an error to think that large fish are in the middle of the river: experience teaches the fallacy of this opinion: they naturally seek their food near the banks, and agitating the waters by an injudicious management of the plumb will certainly drive them away. It is incredible the quantities of barbel sometimes caught by this method. Persons of great veracity have asserted that upwards of one hundredweight have been taken in one morning."

The Chub. (*Cyprinus Cephalus.*)

The rivers of England are stored with a much finer variety of fresh-water fish than those of Scotland. The chub occurs in the Annan. It is however a fish but lightly esteemed, either for sport or the table. He is a dull fish on the hook, bites eagerly, and is soon tired. Caution is requisite on the part of the angler, as the chub is naturally fearful, and sinks towards the bottom of the stream on the slightest alarm. The baits used are maggots, beetles, grasshoppers, salmon-roe, &c. Black and dun flies gaudily dressed, and ribbed with gold or silver twist, are well adapted to take them in streams. They likewise rise at the red-spinner. But perhaps the best way to secure this fish is by *dibbing* with a grasshopper. As chub are often seen in some favourite haunt lying near the surface of the pool, the angler, concealing himself as much as possible, ought to move his rod cautiously over the spot, and drop his bait gently upon the water, a few inches in advance of the fish's head. The landing net is particularly necessary in angling for chub, as the best spots are generally encumbered by trees or bushes, which prevent the fish from being drawn to hand, or pulled ashore.

The Dace. (*Cyprinus Leuciscus.*)

This fish is of gregarious habits, and haunts the deeper waters near the piles of bridges, shady pools, and beneath the masses of collected foam caused by eddies. In the warmer months of the year they also congregate in the shallows. They rise at a variety of flies, and are likewise angled for with red worms, brandlings, &c. Above Richmond, as soon as the weeds begin to rot, a grasshopper used as an artificial fly is found very successful in hot weather among the shallows. This mode can only be practised in a boat, with a heavy stone to serve as an anchor, fastened to a few yards of rope. The boat drifts gently down the stream, and the stone is dropped whenever the angler considers himself in the neighbourhood of a likely place. Standing in the stern, he first throws directly down the stream, and then to the right and left; and after trying for about a quarter of an hour in one spot, he again weighs anchor, and proceeds to another station.

The Roach. (*Cyprinus Rutilus.*)

The carp has been named the "water-fox" on account of his subtlety, and the roach the "water-sheep," by reason of his silliness. This fish makes good soup, though very bony, and otherwise not much esteemed. The season for roach fishing in the Thames, where it attains to a larger size than elsewhere, commences about the end of August. "Next let me tell you," says Walton, "you shall fish for this roach in winter with paste or gentles, in April with worms or caddis, in the very hot months with little white snails, or with flies under water; for he seldom takes them at the top, though the dace will. In many of the hot months roaches may be also caught thus:—Take a May-fly or ant-fly; sink him with a little lead to the bottom, near the piles or posts of a bridge, or near to any posts of a wear—I mean any deep place where roaches lie quietly—and then pull your fly up very leisurely, and usually a roach will follow your bait to the very top of the water, and gaze on it there, and run at it, and take it, lest the fly should fly away from him."[1] Vast shoals of this species ascend the streams in the parish of Killearn, from Loch Lomond, and are caught by nets in thousands. Their emigration from the loch, however, continues only for the space of three or four days towards the end of May.[2]

The Bleak. (*Cyprinus Alburnus.*)

This small and active fish may be angled for with what is called a *pater noster* line, which consists of half a dozen fine hooks fastened about 6 or 8 inches from each other. These may be baited with gentles, or more variously, to increase the temptation, with a gentle, a small red worm, a fly, &c. and thus several fish may be hooked at the same time. In angling for bleak the tackle must be very fine. In fresh streams they rise well at the black gnat, or any other small sad-coloured fly.

The Gudgeon. (*Cyprinus Gobio.*)

Gudgeons are angled for near the ground with a small red worm. They frequent the shallows during the hot months, and retire before winter to the stiller and deeper waters. As an article of food they are highly esteemed.

The Minnow. (*Cyprinus Phoxinus.*)

This is the fish by means of which most youthful anglers commence their experience of the art. "He is a sharp biter," says Walton, "at a small worm, and in hot

[1] *Complete Angler*, p. 218.

[2] *Statistical Account of Scotland*, vol. xvi. p. 100.

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weather makes excellent sport for young anglers, or boys, or women that love that recreation; and in the spring they make of them excellent minnow-tansies; for being washed well in salt, and their heads and tails cut off, and their guts taken out, and not washed after, they prove excellent for that use; that is, being fried with yolks of eggs, the flower of cowslips and of primroses, and a little tansie. Thus used, they make a dainty dish of meat."

The Loach. (*Cobitis Barbatula.*)

The loach is entirely a ground fish, living in clear and gravelly streams. It is an excellent bait for eels, and is also a nutritious food for man, though of a slimy and somewhat forbidding aspect.

The Eel. (*Anguilla Vulgaris.*)

This well-known and snake-like species has its favourite haunts in the muddy bottom of the bays of lakes, among weeds, under large stones, and in the clefts of the banks of rivers. The habits of the eel are nocturnal, and the largest and finest are usually caught with night-lines. They are troublesome fish, from their great tenacity of life, and the tortuous motions by which, in their endeavours to disengage themselves, they entangle or destroy the angler's tackle. They afford little amusement to those accustomed to the more elegant branches of the art.

The isle of Ely, according to some authorities, was so called in consequence of its being the place from whence the kings of England were anciently supplied with eels. Indeed Cambridgeshire is still famous for this fish.[1]

The Perch. (*Perca Fluviatilis.*)

This gregarious fish is angled for with a worm or minnow. It is a bold biter during the warm months of the year, though very abstemious in the winter season. When a shoal is met with, great sport is frequently obtained. A small cork float is used, and the bait is hung at various depths, according to circumstances, a knowledge of which can only be obtained by practice. In angling near the bottom, the bait should be frequently raised nearly to the surface, and then allowed gently to sink again. When the weather is cool and cloudy, with a ruffling breeze from the south, perch will bite during the whole day. The best hours towards the end of spring are from seven to eleven in the morning, and from two to six in the afternoon. In warm and bright summer weather, excellent times are from sunrise till six or seven in the morning, and from six in the evening till sunset.

The first printed work on angling in the English language is by Dame Juliana Barnes or Berners (*The Treatyse of Fysshinge with an Angle*), and forms part of the *Book of St Alban's, emprented at Westmestre by Wynken de Worde*, in 1496. Of this book there are various old editions, and it has, we believe, been twice reprinted in modern times. It is less useful to the angler than curious in the eyes of the bibliographer. Hawking, Hunting, Fouling, and Fishing, with the true measures of Blowing, &c. now newly collected by W. G. Faukener. 4to, Lond. 1596. A Book of Fishing with Hooke and Line, and of all other Instruments thereunto belonginge, made by L. M. 4to, Lond. 1590. This work contains remarks on the preservation of fish in pools, and some improvements on the directions of the "religious sportswoman" Juliana Barnes. L. M. signifies Leonard Mascall. A Neu Book of good Husbandry, very pleasaunt, and of great profite, both for gentlemen and yeomen; conteining the Order and Maner of Making of Fish-pondes, with the Breeding, Preseruing, and Multiplyinge of the Carpe, Tench, Pike, and Troute, and diverse kindes of other Fresh Fish. Written in Latine by Janus Dubrauius, and translated into English at the speciale request of George Churchey, Fellow of Lion's Inne, the 9th Februarie 1599. 4to, Lond. 1599. Certain Experiments concerning Fish and Fruit, practised by John Taverner, Gentleman, and by him published for the benefit of others. 4to, Lond. 1600. The Secrets of Angling; teaching the Choicest Tooles, Baytes, and Seasons for the taking of any Fish in Pond or River: practised and familiarly opened in Three Bookes. By J. D., Esquire. 8vo, Lond. 1613. The author of this work is named in the third edition of Walton's Angler as one Jo. Davors; but, from an entry in the books of Stationers Hall, as given in the second volume of "British Bibliography," p. 355, he is mentioned as John Dennys, Esquire. Large extracts from this work are given by Sir Egerton Bridges, in the last volume of his *Censura Literaria*. The poetry, of which several passages are quoted by Walton, is remarkable for its beauty. As the volume is rare, we shall here present the reader with a few stanzas.

You nymphs that in the springs and waters sweet
Your dwelling have, of every hill and dale,
And oft amid the meadows green do meet
To sport and play, and hear the nightingale,
And in the rivers fresh do wash your feet,
While Progne's sister tells her wofull tale;
Such ayd and power unto my verses lend
As may suffice this little work to end.

And thou, sweet Boyd, that with thy wat'ry sway
Dost wash the cliffes of Deignton and of Week,
And through their rocks with crooked winding way
Thy mother Avon runnest soft to seek;
In whose fair streams the speckled trout doth play,
The roach, the dace, the gudgin, and the bleike;
Teach me the skill, with slender line and hook,
To take each fish of river, pond, and brook.

In comparing the amusement of angling with the excitement to be derived from gaming and other pleasures, he adds—

O let me rather on the pleasant brinke
Of Tyne and Trent possess some dwelling place,
Where I may see my quill and corke down sinke,
With eager bite of barbel, bleike, or dace;
And on the world and his Creatour thinke,
While they proud Thais painted sheet embrace;
And with the fume of strong tobacco smoke
And quaffing round are ready for to choke.

Let them that list these pastimes then pursue,
And on their pleasing fancies feed their fill;
So I the fields and meadows green may view,
And by the rivers fresh may walke at wille,
Among the dazies and the violets blue,
Red hyacinth and yellow daffodil,
Purple narcissus like the morning rayes,
Pale ganderglas, and azore culverkayes.

I count it better pleasure to behold
The goodly compasse of the lofty skie;
And in the midst thereof, like burning gold,
The flaming chariot of the world's great eye;

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[1] "Here I hope I shall not tresspass upon gravity, in mentioning a passage observed by the reverend professor of Oxford, Doctor Prideaux, referring the reader to him for the author's attesting the same. When the priests in this part of the country would still retain their wives, in despight of whatever the pope or monks would doe to the contrary, their wives and children were miraculously turned all into eels (surely the great into *Congers*, the less into Greggs), whence it had the name of EELY. I understand him, a LIE of EELS." (Fuller's *Worthies. Cambridgeshire.*)

The wat'ry clouds that in the ayre uprol'd
With sundry kinds of painted colours flie;
And faire Aurora lifting up her head,
All blushing rise from old Tithonus bed.

The hills and mountains raised from the plains,
The plains extended levell with the ground,
The ground divided into sundry vains,
The vains enclos'd with running rivers round,
The rivers making way thro' nature's chains,
With headlong course into the sea profound;
The surging sea beneath the vallies low,
The vallies sweet, and lakes that lovely flow.

Then follow the two stanzas quoted at the beginning of this article. Our next work on angling is The Pleasures of Princes, or Good Men's Recreations; containing a Discourse of the General Art of Fishing with the Angle, or otherwise, and of all the hidden secrets belonging thereunto; together with the Choyce, Ordering, Breeding, and Dyetting of the Fighting Cocke; being a worke never in that nature handled by any former author. Lond. 1614, 4to. This work forms part of the second book of the English Husbandman, by G. M. (Gervais Markham.) A Briefe Treatise of Fishing; with the Art of Angling. Lond. 1614, 4to. This work is little else than a reprint from a portion of the Book of St Alban's, and forms part of the Jewell for Gentric, by T. S. Cheap and Good Husbandry, by Gervais Markham. 4to, Lond. 1616. This work contains a chapter on Fish and Fish-Ponds. Country Contentments; or the Husbandman's Recreations, by J. M. In the fifth and sixth editions of this volume (4to, Lond. 1633 and 1639), will be found, the Whole Art of Angling, as it was written in a small treatise in rime, and now, for the better understanding of the reader, put into prose, and adorned and enlarged. This work is a prose version, with additions, of Davors' Secrets of Angling. The Country Gentleman's Companion, 2 vols. 12mo, Lond. 1753, is a reprint, without acknowledgement, of Markham's work. The Art of Angling; wherein are discovered many rare secrets very necessary to be known by all that delight in that recreation, written by Thomas Barker, an antient practitioner in the said art. 12mo, Lond. 1651. In an epistle to the reader, prefixed to the first edition, and in the dedication of the two last to Edward Lord Montague, Barker speaks of himself as having practised angling for more than half a century. He also says he was born and educated at Bracemeall, in the liberty of Salop, being a freeman and burgesse of the same city; adding, "if any noble or gentle angler, of whatever degree soever he be, have a mind to discourse of any of these wayes and experiments, I live in Henry the 7th's Gifts, the next doore to the Gatehouse, in Westm. My name is Barker, where I shall be ready, as long as please God, to satisfye them, and maintain my art during life, which is not like to be long." See British Bibliography, by Sir Eg. Bridges and Joseph Haslewood, vol. ii. p. 356. The Compleat Angler, or the Contemplative Man's Recreation; being a discourse of Fish and Fishing, not unworthy the perusal of most anglers. 12mo, Lond. 1653. This is the first edition of Izaak Walton's celebrated work. It went through five editions during the author's lifetime; and in the course of its republication was enlarged and improved. The fifth edition forms the first part of the Universal Angler, by Walton, Cotton, and Venables, 12mo, Lond. 1676; and is accompanied by a *second part* (written by Cotton), which treats more fully of fly-fishing. The sixth and seventh editions were published in 1750 and 1759, by Moses Browne, author of the Piscatory Eclogues and other works. The eighth edition was published by Sir John Hawkins in 1760, and has been succeeded by many others since that period, of which the most recent and most beautifully adorned is that by John Major, with an introductory essay and illustrative notes. 8vo, Lond. 1823. The third edition of the Compleat Gentleman, by Henry Peacham, 4to, Lond. 1661, contains a chapter concerning Fishing. The Experienced Angler, or Angling Improved; being a general discourse of Angling. 8vo, Lond. 1662. This work, of which there are several editions, is by Colonel Robert Venables. Its fourth edition forms the third part of the Universal Angler. Angling Improved to Spiritual Uses, forms part of an octavo volume entitled Occasional Reflections upon several Subjects, by the Hon. Robert Boyle. 8vo, Lond. 1665. In a volume called The Epitome of the Art of Husbandry, by J. B. Gent. 12mo, Lond. 1669, are brief experimental directions for the right use of the angle. The author's name was Blagrave. The Angler's Delight; containing the whole Art of Neat and Clean Angling; wherein is taught the readiest way to take all sorts of Fish, from the Pike to the Minnow, together with their proper baits, haunts, and time of fishing for them, whether in mere, pond, or river. As also the method of fishing in Hackney River, and the names of all the best stands there; with the manner of making all sorts of good tackle fit for any water whatsoever. The like never before in print. By William Gilbert, Gent. 12mo, Lond. 1676. The Compleat Troller, or the Art of Trolling, by Robert Nobbes. 8vo, Lond. 1682. There are several editions of this work, of which the third and fourth are appended to the Angler's Pocket-Book. Gentleman's Recreations; treating of the Art of Horsemanship, Hunting, Fowling, Fishing, and Agriculture. Fol. Lond. 1686. The Gentleman's Recreation, in four parts, viz. Hunting, Hawking, Fowling, Fishing. 8vo, Lond. 1674. (By Nicholas Cox.) The Angler's Vade Mecum, or a compendious yet full Discourse of Angling. By T. Chectham. 8vo, Lond. 1681. Northern Memoirs, calculated for the meridian of Scotland; wherein most or all of the Cities, Citadels, Seaports, Castles, Forts, Fortresses, Rivers, and Rivulets, are compendiously described; to which is added, the Contemplative and Practical Angler, by way of diversion; with a Narrative of that dextrous and mysterious Art experimented in England, and perfected in more remote and solitary parts of Scotland; by way of Dialogue: writ in the year 1658, but not till now made publick. By Richard Franck, Philanthropus. 8vo, Lond. 1694. Of this curious volume a reprint was published of late years. The Gentleman Fisher; or the Whole Art of Angling. 8vo, Lond., second edition, 1727. The True Art of Angling, by J. S. 24to, Lond. 1696. The Compleat Fisher, or the True Art of Angling, by J. S., third edition, 1704. The preceding work, revised and corrected by W. Wright and other experienced anglers, was republished in 1740. The Compleat Fisherman; being a large and particular account of all the several ways of Fishing now practised in Europe; by James Saunders, Esq. of Newton-Awbery, upon Trent. 12mo, Lond. 1724. The Genteel Recreation, or the Pleasure of Angling; a Poem: with a dialogue between Piscator and Corydon. By John Whitney, a lover of the Angle. 8vo, Lond. 1700. The School of Recreation, or a Guide to the most ingenious Exercises; by R. H. 8vo, Lond. 1701. The Secrets of Angling, by C. G. 12mo, Lond. 1705. The Angler's Sure Guide, or Angling Improved and Methodically Digested, by R. H. Esq. 8vo, Lond. 1706. The Innocent Epicure, or the Art of Angling; a Poem. 8vo, Lond. 1697. The whole Art of Fishing, being a Collection and Improvement of all that has been written on this subject; with many new experiments. 12mo, Lond. 1714. The second edition of this work is entitled The Gentleman Fisher, or the whole Art of Angling. 8vo, Lond. 1727. A Discourse of Fish and Fish-Ponds, by a Person of Honour. 8vo, London.

Angling.

The author of this work was the Hon. Roger North. A subsequent edition (of which there were more than one) bears the date of 1713. It was also published as an appendage to the Gentleman Farmer. 8vo, Lond. 1726. The Country Gentleman's Vade Mecum, by G. Jacob, Gent. 8vo, Lond. 1717; and the Compleat Sportsman, by the same author (1718), of which the 3d part relates to Fish and Fishing. England's Interest, or the Gentleman and Farmer's Friend, by Sir John Moore. 8vo, Lond. 1721. The Gentleman Angler, Lond. 1726. Piscatory Eclogues (by Moses Browne). 8vo, Lond. 1729. Of this work there are several editions. Sportsman's Dictionary, or the Gentleman's Companion in all Rural Recreations. 2 vols. 8vo, 1735. The British Angler, or a Pocket Companion for Gentlemen Fishers, by John Williamson, Gent. 8vo, Lond. 1740. The Art of Angling, Rock and Sea Fishing, with a Natural History of River, Pond, and Sea Fish, by R. Brookes. 8vo, Lond. 1740. Of this treatise there have been various reprints, at different periods, up to the year 1807. Angling, a Poem. 12mo, Lond. 1741, 2d edit. The Art of Angling improved in all its Parts, especially Fly-fishing, by Richard Bowlker. 12mo, Worcester. Published some time preceding the year 1759. There is a recent edition (1806) by Charles Bowlker, Ludlow. The Angler's Magazine, or Necessary and Delightful Store House; wherein every thing proper to be known relating to his art is digested in such a method as to assist his knowledge and practice upon bare inspection; being the completest manual ever published upon the subject, largely treating of all things relating to Fish and Fishing, and whereby the angler may acquire his experience without the help of a master. By a Lover of that innocent and healthful diversion. 12mo, Lond. 1754. The Angler's Eight Dialogues, in Verse. 8vo, Lond. 1758. The Art of Angling, eight Dialogues, in Verse. 8vo. The Universal Angler, or that art Improved in all its Parts, especially in Fly-fishing. 8vo, Lond. 1766. The Complete Sportsman, or Country Gentleman's Recreation, by Thomas Fairfax. 8vo, London. The Complete Fisherman, or Universal Angler. 8vo, Lond. (2d edit.) Lond. 1778. The Angler's Complete Assistant, being an Epitome of the whole Art of Angling. 4th edit. 4to, London. The True Art of Angling. 12mo, Lond. 1770. Translation of a Letter from the Hanover Magazine, No. 23, March 21, 1763; giving an account of a method to breed fish to advantage. 8vo, Lond. 1778. The Angler's Museum, or the whole Art of Float and Fly Fishing, by Thomas Shirley. 12mo, Lond. 1784. The Fisherman, or Art of Angling made Easy, by Guiniad Charfey, Esq. 8vo, London. The North Country Angler, or the Art of Angling as practised in the Northern Counties of England. 8vo, Lond. 1786. A Concise Treatise on the Art of Angling, by Thomas Best, Gent. 8vo, Lond. 1787. Of this work there have been published many editions, of which the 9th is dated 1810. An Essay on the Right of Angling in the River Thames, and in all the other public Navigable Rivers. 8vo, Reading. A Letter to a Proprietor of a Fishery in the River Thames; in which an attempt is made to show in whom the right of Fishing in public streams now resides. 2d edit. 8vo, Reading, 1787. The Natural History of Fishes and Serpents, by R. Brookes; to which is added, an Appendix, containing the whole Art of Float and Fly Fishing. 8vo, Lond. 1790. The Young Angler's Pocket Companion, by Ralph Cole, Gent. 12mo, Lond. 1795. The Modern Angler, being a practical Treatise on the Art of Fishing, &c., in a series of Letters to a Friend; by Robert Salter, Esq. 12mo, London. Angling in all its branches reduced to a complete Science, in three parts, by Samuel Taylor, Gent. 8vo, London, 1800. Practical Observations on Angling in the River Trent. 8vo, Newark, 1801. Every Man his own Fisherman, by Thomas Smith. 24to, London. The Driffield Angler, in two parts, by Alexander Mackintosh of Great Driffield, Yorkshire. 8vo, Gainsborough. The Angler's Pocket Book; to which is prefixed, Nobbes' celebrated Treatise on the Art of Trolling. 8vo, Norw. The New and Complete Angler, or Universal Fisherman, by Richard Pollard, Esq. of Clapton, Middlesex. 8vo, Lond. 1802. Rural Sports, by W. B. Daniel. 4to, Lond. 1802. Part of vol. ii. relates to fly-fishing, and the other kinds of angling. The Kentish Angler, or the Young Fisherman's Instructor; showing the nature and properties of Fish which are angled for in Kent. 12mo, Canterb. 1804. The Complete Angler's Vade Mecum, being a perfect Code of Instruction on the above pleasing Science, &c., by Captain T. Williamson. 8vo, London, 1808. The Angler's Manual, or concise Lessons of Experience, which the proficient in the delightful recreation of Angling will not despise, and the Learners will find the advantage of practising; containing useful Instructions on every approved method of Angling, and particularly on the management of the Hand and Rod in each method. 4to, Liverpool, 1808. The Fisher's Boy, a Poem, by W. H. Ireland. 8vo, 1808. The Angler's Manual, or concise Lessons of Experience, &c. 8vo, 1809. Practical Observations on Angling in the River Trent. 12mo, 1812. Daniel's Rural Sports. Royal 8vo, 1812. Howitt's Foreign Field Sports, Fisheries, &c. 4to, 1814. The Secrets of Angling, by J. D. (Davors); augmented by W. Lawson. 8vo, 1814. The Angler's Guide, by T. F. Salter. 8vo, 1815. Art of Angling, by Charles Bowlker. 12mo, 1815. The Fly-Fisher's Guide, by G. C. Bainbridge. 8vo, 1816. W. H. Scot's British Field Sports. Royal 8vo, 1818. The Angler's Vade Mecum, by W. Carroll. 12mo, 1818. Sportsman's Repository, by J. Scott, 1820. The Troller's Guide, a new and complete Practical Treatise on the Art of Trolling for Jack and Pike; to which is added, the Best Method of Baiting and Laying Lines for large Eels. By T. F. Salter, author of the Angler's Guide. Small 8vo, Lond. 1820. Instructions to Young Sportsmen, by Lieutenant-Colonel Hawker. Royal 8vo, 1824. Salmonia, or Days of Fly-Fishing. By an Angler (the late Sir Humphry Davy). 12mo, Lond. 1828.

The preceding extensive list will probably suffice for the instruction and guidance of the most studious angler. Those who are curious in regard to bibliographical details concerning the different editions of the earlier works may consult a *Catalogue of Books on Angling*, 8vo, 1811, published by Mr Ellis of the British Museum, and originally printed in the *British Bibliographer*. (T.)

Explanation of Plate XLV.

Fig. 1. Salmon-fly for spring.
2. Ditto ditto.
3. Ditto ditto.
4. Ditto for summer.
5. Ditto ditto.
6. Ditto for spring.
7. May fly.
8. Red-brown fly.
9. Green-drake fly.
10. Ditto.
11. Dun cut fly.
12. } Minnow-tackle
13. } hooks, baited.
14. Moth fly.
15. Palmer fly.
16. Ditto.
Fig. 17. Ant fly.
18. Hawthorn fly.
19. Minnow-tackle.
20. Gorge hook and baiting-needle.
21. Dead-snap with four hooks.
22. Dead-snap with two hooks, baited.
23. Live bait double hook, baited.
24. Gorge hook, baited.
25. Live bait single hook, baited according to two different methods.

ANGLO-CALVINISTS, a name given by some writers o the members of the church of England, as agreeing vith the other Calvinists in most points except church overnment.

Anglo-Saxon, an appellation given to the language poken by the English Saxons, in contradistinction to the rue Saxon, as well as to the modern English.

ANGLUS, Thomas. See White, Thomas.

ANGOLA, an extensive coast and territory of Western Africa, extending to the south of the river Congo or Zaire. According to Degrandpré, the name is given to he whole coast, from Cape Lopez Gonsalvo, in 0. 44. to St Phelipe de Benguela, in lat. 12. 14. S., a range of nearly 12 egrees, or about 800 miles. The country strictly called Angola, however, occupies only the middle part of this pace between Congo on the north and Benguela on the outh, being watered by the large rivers Coanza and Dando, to the former of which especially, the Portuguese naps assign a very long course through the interior; but either of these rivers has been ascended to any considerable height.

From the early Portuguese accounts, it would appear hat Angola or Ngola was a title assumed by the kings, nd transmitted by one to another from the original ounder of their dynasty. The first Ngola was reported y tradition to have been raised to distinction by the skill vith which he exercised the occupation of a smith; and hough this mode of elevation may be somewhat foreign o our ideas, yet this trade is in its products so important o a warlike people, and in the infancy of art is attended vith such difficulty, that among the nations of Africa gerally it is held in peculiar honour. Ngola seems also o have secured the attachment of his countrymen by vaious benefits, particularly by forming a store of grain, rom which, during periods of scarcity, he supplied their ecessities. Among his successors, several were fierce nd warlike; one, in particular, named Chilivagni Angola, reatly extended the boundaries of the kingdom, making comprehend Matamba and great part of Benguela. His uccessor Bandi Angola, however, being hard pressed y the Giagas, a fierce and wandering tribe from the nterior, applied for aid to the king of Congo, and was ided by a body of Portuguese, who were then established n that territory. Through their valour and discipline Bandi was enabled to repel the invaders, and was thus nduced for some time to lavish on the strangers the ighest honours. Becoming, however, jealous of their ower, and perhaps disgusted with their haughty deportment, he formed a scheme to cut them off, which they scaped only partially, and by a very hasty flight. Reurning to Portugal, they recommended very strongly Anola as a theatre both of commerce and conquest,—an dvice highly accordant with the enterprising and ambious views by which that court was then actuated.

The river Congo had in 1484 been discovered, and in ome degree explored, by Diego Cam; but his successors, Bartholomew Diaz and Vasco de Gama, when sailing long the coast to the southward, were solely intent on eaching and passing the dangerous cape which formed he utmost boundary of the African continent. After the plendid discoveries and settlements attempted to be ormed on the coast of India, the Almeidas and the Alluquerques pushed onwards to that region without allowing themselves to be detained by undertaking any settlements on this barbarous coast. The king, however, bout the middle of the 16th century, sent out an armament under Paulo de Diaz, a descendant of Bartholomew, constituting him viceroy of all the territories which e should conquer in this part of Africa. Diaz landed, nd established the Portuguese headquarters at a place which he called Loando St Paul, near the mouth of the Coanza; then proceeded with an armament up that river, and erected a fort on its banks, whence his troops began to spread over the surrounding country. The king, unable to brook such rivals to his power, assembled an army, which, with absurd exaggeration, is represented as exceeding 100,000 men. It was probably, indeed, much superior in numbers to the handful which the Portuguese could oppose to it; but such was their superiority in arms and discipline, that both the king, and his son, who soon succeeded him, were beaten in successive encounters. At length there arrived, as ambassadress at the camp of the Portuguese, no less a person than the king's sister, Zingha Bandi, whose manners and address struck them with surprise and a sort of admiration. They relate, that on being introduced to Don John, who had succeeded to the rank of viceroy, and seeing no chair provided for her, without making any complaint, she caused her attendant to bend down on her hands and knees, and made use of her back as a seat. A demand being made of vassalage and tribute, she rejected it with indignation; and it was finally agreed that both parties should remain in their present position, and a mutual exchange of prisoners take place,—terms which leave much room to doubt if the successes of the Portuguese were so decided as they chose to represent. Zingha, on the whole highly pleased with her reception, remained with them a considerable time, during which she became a convert to Christianity, and finally parted on the most friendly terms.

The Portuguese were not long in receiving very unfavourable tidings of their new convert. By the murder of her brother and his son, she paved her way to the sovereignty; and then began, equally with her predecessors, to feel deep dissatisfaction at the great extent of valuable territory possessed by this foreign nation. Unable to hope for its recovery by fair means, she formed alliances with the neighbouring states, and even with the ferocious and formerly hostile tribe of Giagas; after which she commenced war, and for many years carried it on with the utmost fury, putting to death, amid the most cruel tortures, all Europeans who fell into her hands. The Portuguese boast of their numerous victories over Zingha; yet admit that they were often very hard pressed, and had at one time their whole force cooped up and closely besieged on an island in the Coanza. They were at the same time involved in war with the Dutch, who in 1641 took their principal settlement of St Paul de Loando, which was recovered, however, by an expedition sent thither on the 15th August 1648. As Zingha rejected all terms of peace which did not include the entire restoration of the conquered country, the Portuguese endeavoured to set up in opposition to her two successive members of the royal family, whom they called John I. and II.; but these phantom monarchs never enjoyed any weight with the people in general. At length the queen, having attained to an advanced age, being no longer seconded by the Dutch, and finding all her efforts to expel the Portuguese abortive, listened to overtures of peace. She indignantly rejected any demand of homage, or of the most trifling tribute; and the treaty was concluded altogether on equal terms, except that she paid a high ransom for one of her sisters, who had fallen into the hands of the Portuguese. Permission was then obtained to send missionaries to her coast, who persuaded her to resume the profession of Christianity, which she had renounced during her long period of enmity; and, on the 15th July 1662, her union with the church of Rome was celebrated with extraordinary pomp.

Zingha died at the age of eighty, and the crown then devolved on her sister's husband Mona Zingha, who com-

Angola.

menced a violent war against the Europeans, which was in a few years terminated by his death. Since that time the affairs of the Portuguese have been involved in that mystery which they studiously throw over all their colonial transactions; but it is not believed that they now occupy more than a very limited range of territory around their ports of St Paul de Loando and St Phelipe de Benguela, which they maintain for the purpose of carrying on the slave-trade.

The whole of this coast, according to Degrandpré, to whom we are indebted for the only recent account of it, has been singularly favoured by nature. The soil consists generally of a rich black loam, fitted for yielding in the utmost luxuriance all the productions of tropical climates. In its present uncultivated state, it is covered with dense and varied vegetation. The forests reach to the top of the hills, and their trunks are often washed by the waves. This vegetation bears generally the same character as in other parts of tropical Africa. Some of the trees, under the influence of heat and moisture on a rich soil, arrive at the most extraordinary dimensions. Mention is made of the *mapou*, which seems to be the same species with the calabash of Adanson, and whose trunk it has required a boat's crew, with arms extended, to embrace. This huge production of nature is unfortunately incapable of being applied to any use whatever: the wood, moist and spongy, is fitted neither for carpentry nor even fuel; the fruit is small and unpalatable; the foliage too scanty to afford any grateful shade. On the other hand, the family of the palms are profusely distributed, and minister to the most important uses of human life. The cocoa-palm, in particular, serves almost every economical purpose. Its juices afford both food and drink; its wood is hard and durable; its filaments form strong ropes; the leaves afford a roofing which resists the rain; even the rind of the fruit is made into vessels for domestic purposes. The date-palm exists, but the soil is too moist to produce it in abundance. The culinary vegetables of Europe, when planted, grow to an extraordinary size, but soon degenerate in a soil which appears foreign to their nature. Cultivation is confined to small spots resembling gardens, in the immediate vicinity of the towns and villages, leaving all the open country in a state of nature. Its efforts are chiefly bestowed on the manioc, plantations of which surround all the villages; and the root, ground down by a species of mill, and then dried in little furnaces, affords the bread generally used in the country.

The animal races are numerous, all wild, and of the same species which generally prevail throughout Africa. Elephants are less numerous than in some other quarters; but hyænas, ounces, and tiger-cats people the forests; and there are all the various species of antelope. Apes and monkeys of various and often peculiar species fill all the woods; and some are distinguished by a remarkable share of intelligence. It seems chiefly in this quarter of the continent that the orang-outang, called by the natives *kimpezey*, sometimes, though rarely, makes his appearance. Degrandpré saw one on board a slave-vessel four feet two inches high, of a mixed red and black colour, and which seemed almost to make an approach to the intellect as well as the form of humanity. It assisted the sailors in drawing the ropes, and was employed to heat the oven, giving notice to the baker exactly at the time when it was fit to receive the bread. Here also are found in great numbers those remarkable insects, the termites or white ants, with their conical structures raised three feet from the ground, and which often destroy in a short time the slight habitations of the natives, with every thing they contain. The inhabitants of this coast rank below those of the rest of the continent, in not having succeeded in taming any description of domestic animals. They have neither horses, asses, oxen, nor sheep, of which last two species such large herds are in the possession of the most barbarous among the other African tribes. The Portuguese reared them in great numbers round their settlement of Loando, whence individuals occasionally strayed into the bordering districts; but no care having been taken to preserve them, they were soon either killed by the natives, or devoured by wild beasts.

The mineral character of this region seems not without interest, though very little explored. Little scope is indeed afforded for geological observation, the surface being everywhere covered with a deep stratum of clay, from beneath which, even on the highest hills, no trace of rock is discoverable; nor have petrifactions or marine remains been anywhere observed. The metallic products, however, are supposed to be of importance, though neither examined nor turned to account. The indications of iron are very widely diffused; but the Angolans are supplied by European powers with all they require. Copper, to the utmost extent of their wants, is found on the surface of the ground. The Portuguese are said to work gold-mines of considerable value in the vicinity of Loando; but the nature and amount of these is studiously concealed, and perhaps exaggerated.

The nations on the coast of Angola seem to rank lower in the scale of improvement than almost any other native African race, except the Hottentots. Their habitations are formed merely of straw, or rather dried leafy plants, cemented by a frame-work of wooden stakes. Containing no aperture for the admission of light, they form not so properly houses, as dark dens for sleeping in, while the tenants spend the day and receive company in an open space in front, covered with a slight roof. The abodes of the grandees are in no respect superior, except that they consist of a number of these hovels grouped together, and inclosed by a hedge or earthen wall. A village or town consists merely of a cluster of these inclosures, separated by narrow and winding footpaths, and leaving extensive open spaces, which serve for markets or for scenes of recreation. Loango, which seems to be the largest native town, though four leagues in circuit, is not supposed to contain above 15,000 inhabitants. A town in this country at a little distance resembles a wood, from the multitude of trees with which it is filled; but on a near approach its nature is soon detected by the fetid odour exhaling from its precincts.

The people on this coast, like most rude nations in a tropical climate, wear scarcely any clothes, yet studiously load their persons with ornaments. Even the rich wear only a cotton cloth round the middle, hanging down to the knee; but their legs and arms are profusely covered with rings of iron or copper, while strings of beads or coral are fastened round the neck, or hang down the breast. Peculiar pride is felt when they can procure a cast-off European suit, covered with gaudy colours and tarnished embroidery. This they display in triumph for several days, when, becoming tired, they bestow it on one of their inferiors.

The natives here, like other unenlightened tribes, are deeply addicted to superstition; and it is remarked as a singular circumstance, that their idols do not present at all the negro visage, but one more nearly approaching to the European. From the slight description that is given, we should suspect the face to be Copt; nor does it seem improbable that the superstitions of Egypt may have found their way throughout the continent. The priests pretend to bestow rain, favourable winds, and various other blessings, upon those who have propitiated them by liberal gifts. Much use is made in criminal cases, of what our

ancestors called "the judgments of God." The accused is made to swallow poison, to plunge into water, or to take in his hand burning coals, and, unless he escapes unhurt from these trials, is at once pronounced guilty. It seems reasonably concluded, that the priests who administer these tests contrive to secure immunity to their favourites, or to those who bestow upon them liberal donations. M. Degrandpré considers it as marvellous that such a coincidence should exist between the customs of Africa and those of Europe during the middle ages; but both are derived from the same principle in human nature; and indeed nothing can appear more probable to the uncultivated mind, which has made little observation on the actual course of nature, than the idea that a special interposition will take place in favour of innocence.

The government of these countries seems established on a species of feudal polity. Each town or village has a sovereign of its own, in whose family the dignity is hereditary; but a number of these princes pay homage and perform certain services to a general head of the nation. Most of the great capitals are situated at some distance in the interior. The succession is transmitted exclusively in the female line. The son of a prince has no dignity above the rest of the nation. The son of a princess alone is a prince by birth, or capable of succeeding to the crown. This is a custom not without example in rude states; and the dissolute manners prevalent and sanctioned in this country seem to afford otherwise no security that the offspring will be of royal blood.

The only employment carried on with any activity throughout these countries seems to be the trade in slaves. The personage next in dignity to the sovereign is the Masook, who conducts all the royal sales, levies the duties, and regulates all the transactions of the private merchants. The engagement entered into by Portugal not to practise this odious traffic to the north of the line does not extend to this coast, where it appears to be carried on still on an immense scale. The slaves imported into Brazil in the year 1828 are said to have amounted to 46,000, who, with the exception of 3000 or 4000 from Mosambique, must all have been drawn from Angola. St Paul de Loando is supposed by Malte-Brun to contain 3000 white inhabitants, besides a much greater number of negroes. An abundant supply of provisions is drawn from the surrounding country, but the water is bad. The Portuguese hold also St Phelipe de Benguela.

Vessels destined for the coast of Angola, after reaching Cape Verde, have two routes by which they may proceed. They may take the *short* route by steering directly along the African coast, through the Gulf of Benin. If favoured by winds and currents, they may make this voyage very speedily; but in the event of these circumstances proving adverse, they are liable to great detention; and the navigation has even occupied eleven months. The other, called the *long* route, is performed by proceeding due south, and even south-west, till they pass the 20th degree of latitude, when a favourable wind and tide carries them directly eastward to the African coast. This route necessarily occupies a considerable time; but it is liable to no vicissitude, and the period may be calculated almost to a day.

ANGON, in the ancient military art, a kind of javelin used by the French. They darted it at a considerable distance. The iron head of this weapon resembled a fleur-de-luce. It is the opinion of some writers that the arms of France are not fleurs-de-luce, but the iron point of the angon or javelin of the ancient French.

ANGORA, Angura, or Ankora, a city of Asia in Anatolia, the ancient Ancyra, situated on a stream called Tabana. It is large and neatly built, and its streets are causewayed with large blocks of granite, but have no footpaths. Its position is lofty and imposing, surrounded by mountains, with numerous gardens which yield the finest fruits. The city was celebrated in the ancient world for its fine edifices; and it still contains the remains of its former grandeur. In its streets are to be seen pillars, some of porphyry, and jasper, and fine marbles. The city has been encompassed by a substantial wall, apparently double in some places, formed of durable stone. Some of the gates exhibit Greek inscriptions, and the masonry is intermixed with pillars, architraves, capitals, and other ancient ornaments. The vestiges of an amphitheatre are still to be seen, and the ruins of a magnificent coria or senate-house, of Corinthian architecture, with inscriptions complimentary to Augustus, in whose reign Angora was built. The inhabitants are distinguished in Natolia for their polished manners: they consist of Mahometans and Christians, there being 9000 of the latter, who are subjected to grievous tyranny and exactions from the former. The Christians have a Greek and an Arminian archbishop, and seven churches. Although the trade and population of this place have declined, a great quantity of yarn, Angora stuffs, and shawls, are still manufactured. The shawls, which rival those of Cashmere, are fabricated from the hair of the Angora goat, which is of a fine silken texture. The soil of the adjacent territory is entirely employed in rearing these animals; and the city is supplied with grain from a distance. This city was constituted the capital of Galatia by Nero. It was taken by the Saracens, and afterwards by Tamerlane in 1402, after the battle in which Bajazet was overthrown. The population, which was formerly 80,000, does not now exceed 20,000. 212 miles E. S. E. of Constantinople. Long. 33. 18. E. Lat. 40. 4. N.

ANGOT, a considerable province in the southern part of the kingdom of Abyssinia, which Alvarez, who visited it in the sixteenth century, describes as an extremely rich and beautiful territory. It has not since been reached by any European traveller, and is entirely in the possession of the Galla, who have overrun all the central provinces of Abyssinia. The tribe now in possession of Angot is called the Betzuma Galla.

ANGOU, a small province in the kingdom of Congo, of which, nearly two centuries ago, it rendered itself independent. It extends along the northern bank of the Congo or Zaire, from its junction with the sea upwards. A great proportion of the surface is covered with forests and swamps: cultivation has made little progress, and the population is thin. Captain Tuckey's expedition must have sailed along the coast of Angou, though it did not recognise it under that name, which was given by the old Portuguese writers. Bomangoi, in the interior, is stated to be the capital; but Cabenda, near the mouth of the Zaire, is the seat of trade, which consists chiefly in slaves, and was considerable previous to the prohibition of that traffic by the British government. See Congo.

ANGOULEME, an arrondissement in the department of the Charente in France, extending over 556 square miles, or 355,840 acres. It is divided into nine cantons, and these again into 144 communes, with 118,871 inhabitants. The chief city, of the same name, contains 2101 houses, 15,011 inhabitants, a cathedral, an hospital, and seven churches.

ANGOUMOIS, formerly a province of France, now a district, bounded on the north by Poitou, on the east by Limosin and Marche, on the south by Perigord, and on the west by Saintonge. Through this province run the rivers Touvre and Charente. This last is full of excellent fish; and though it often overflows its banks, it is so far from doing any damage, that it greatly enriches the

Angra || Anhalt-Bernburg.

soil. The Touvre is full of trouts. The air is generally warmer than at Paris, though the country is hilly. The soil produces plenty of wheat, rye, oats, Spanish corn, saffron, grapes, and all sorts of fruits. Here are several iron mines, which yield a very good sort of iron.

ANGRA, a city of Tercera, one of the Azores; the capital, not only of that island, but of all the group, and the residence of the governor. It is seated on the southern shore, and the harbour is the only tolerable one in the whole island. It is in the form of a crescent, the extremities of which are defended by two high rocks, that run so far into the sea as to render the entrance narrow, and easily covered by the batteries on each side. From this harbour the town is said to derive its name, the word *Angra* signifying a creek, bay, or station for ships. Here ships may ride in great safety during the summer; but as soon as the winter begins, the storms are so furious, that the only safety is in putting to sea with all possible expedition. Happily these storms are preceded by infallible signs, with which experience has made the inhabitants perfectly acquainted.

The town is well built and populous, and forms the see of a bishop, under the jurisdiction of the archbishop of Lisbon. It contains five parishes, a cathedral, four monasteries, as many nunneries, besides a bishop's court, which extends its jurisdiction over all the Azores. The fortifications are strong, but not in good repair.

At Angra are kept the royal magazines for anchors, cables, sails, and other stores for the royal navy, and occasionally for merchant vessels in great distress. All maritime affairs are under the inspection of an officer, *Desembergrador*, who has subordinate officers and pilots for conducting ships into the harbour, or to proper watering places. The English, French, and Dutch, have each a consul residing at Angra, though the commerce of any of these nations with the Azores is very inconsiderable. Long. 27. 14. W. Lat. 38. 38. N.

ANGRI, a town with 4426 inhabitants, in the province of Principato Citeriore, in the kingdom of Naples.

ANGUILLIFORM, an appellation given by zoologists, not only to the different species of eels, but to other animals resembling them in shape.

ANGUINUM OVUM, a fabulous kind of egg, said to be produced by the saliva of a cluster of serpents, and possessed of certain magical virtues. The superstition in respect to these was very prevalent among the ancient Britons, and there still remains a strong tradition of it in Wales. This wondrous egg seems to be nothing more than a bead of glass, used by the Druids as a charm to impose on the vulgar, whom they taught to believe that the possessor would be fortunate in all his attempts, and that it would gain the favour of the great.

ANGUS, a district of the county of Forfar, in Scotland. It was an earldom belonging to the Douglases, now extinct.

ANGUSTICLAVIA, in *Roman Antiquity*, a tunica embroidered with little purple studs. It was worn by the Roman knights, as the laticlavia was by the senators.

ANHALT-BERNBURG, one of those small independent sovereignties still left in Germany, and one of the monuments of its ancient state. The sovereign bears the title of duke. His territories are much scattered between the Hartz forest and the rivers Saale and Elbe. Their whole extent is nearly 242 square miles, or 154,880 English acres. It is divided into two parts, each of which is denominated a duchy. The upper duchy lies on the side and at the foot of the Hartz Mountains, and, though hilly and woody, has in it some beautiful valleys. The lower duchy, on the Elbe, is a flat marshy district, but the part which touches the Saale is dry and healthy. In the lower duchy the climate is temperate and mild, but in the upper it is cold and raw, the harvests are late, and the fruits rarely come to perfect ripeness. The principal products are corn, flax, rapeseed, tobacco, garden fruits, and some wine. The country abounds with game, and the lakes and rivers with fish. There are some mines, which yield silver, copper, iron, sulphur, alum, and gypsum. The inhabitants in 1817 were 37,046, in 7 cities, 54 villages, and 33 hamlets, and are all of the Protestant profession. The chief employment is agriculture, the next is mining, and preparing the metals; but some little woollen cloth and paper are manufactured. The sovereign rules without limitation. The revenue of the state is about L.45,000 annually, of which L.9000 is derived from the royalties of the forests and mines. The remainder is chiefly derived from the patrimonial lands of the prince, and a part from taxes imposed on the subjects, who are mostly in poor circumstances. The military force required for the contingent is 370 men, of whom 120 are kept up, but the landsturm, a kind of militia, including every man between 20 and 30, amounts to 7000, only 30 of whom have fire-arms. (G.)

ANHALT-DESSAU, an independent sovereignty in Germany, with the title of duchy. It takes the first name from the family that governs it, and the second from the chief place in the territory. The greater part lies in a compact manner on the left bank of the Elbe, and on both sides of the Mulde. The other parts are scattered and separated from each other by the dominions of other princes. It is in general a level country, and the compact part on the left bank of the Elbe is cultivated with great care, and yields abundant produce; and though, in the scattered parts on the right bank of that river, there are some heaths and a poorer soil, yet the whole produces sufficient necessaries for its dense population. The whole duchy is divided into 15 amts or bailiwicks. Its extent is 363 square miles, or 232,320 English acres. The number of inhabitants in 1817 amounted to 52,947, living in 8 cities, 2 market-towns, and 115 villages and hamlets. The almost exclusive employment is husbandry, except that the females spin both linen and woollen yarn. All kinds of grain are raised. Flax, rapeseed and its oil, hops, madder, fruit, especially apples, wood, butter, cheese, game, and fish, are conveyed to the great markets of Berlin and Leipsic, and constitute the external trade. With the exception of 1200 Jews and two Catholic congregations, the whole of the inhabitants are Protestants, with 32 reformed and 21 Lutheran churches. The revenue of the state amounts to L.70,000 annually, of which the personal domains of the duke produce L.20,000; the remainder arises from his feudal dues, and from some moderate taxes. It has no debt, and is the most favoured part of Germany. Though it suffered dreadfully by the war in the year 1813, it was enabled very speedily to recover from its losses, by the productive qualities of its soil, and the parsimonious industry of its cultivators. The whole military force is nominally 600 men, but scarcely an eighth are mustered at any one time. (G.)

ANHALT-KOTHEN, an independent duchy in Germany. It consists of four fragments, intermingled with the territories of surrounding princes. The most compact portion are the three bailiwicks around the capital. The duchy is on both sides of the river Elbe, though only one of its towns, Roslau, comes in contact with that stream, the others reaching it by the rivers Ziethe, the Saale, the Ruthe, or the Wipper. The land is generally a level plain, in some parts with a sandy soil, but for the most part well cultivated, especially on the left side of the Elbe, and very productive. The extent of the dominion is 324 square miles, or 140,800 acres. It is divided into nine amts or bailiwicks, and comprehends four cities, one market-town,

and 106 villages and hamlets. The inhabitants in 1817 were 32,454, nearly all Protestants, the Lutherans having 19, and the reformed 28 churches. Husbandry is almost the exclusive occupation, and there is no other trade than that of exchanging its surplus productions for foreign commodities. The chief of that surplus consists of corn, wool, and fruit, especially apples, with which the duchy supplies Berlin to a great extent. The revenue amounts to about L.23,000 sterling, of which the ducal patrimony in Silesia forms L.9000. The state has a debt which in 1816 amounted to L.160,000; but, by means of a sinking fund, which was then established, it has been regularly diminishing. There are no military beyond a small body-guard. A militia is established, but not called out. The duke, besides this land, is also in possession of the principality of Plesse, in the Prussian province of Silesia, and, in right of it, is a member of the states of that country. (G.)

ANHOLT, a Danish island in the Cattegat, 32 miles north-east of Greenæ, and 36 south-west from Lassoe. It is a barren spot, scarcely affording subsistence to 100 inhabitants, who from their language, which is Erse mixed with a few Danish words, are supposed to be emigrants from the Highlands of Scotland. Their chief pursuit is fishing. It is surrounded by dangerous banks of sand, for which reason a light-house is built on it, the occupation of which was a subject of contest with England during the war. It is in lat. 56. 32. 2. N. and long. 11. 49. 17. E.

ANJAR, a fortified town of Hindostan, and capital of a district of the same name, in the province of Cutch, which was ceded to the British government in 1816. The country is dry and sandy, and depends entirely on irrigation by means of wells, the expense of sinking which is great. The town is situated nearly 10 miles from the gulf of Cutch. In 1816 it surrendered to the British. It suffered severely from an earthquake in 1819, about 3000 houses being either destroyed or rendered uninhabitable, and 165 persons having lost their lives; while the other half of the town, situated on low rocky ridges, suffered comparatively nothing. In 1820 the population was estimated at 10,000. The port named Toonea is fronted by a creek from the gulf. Long. 70. 11. E. Lat. 23. 3. N.

ANIELLO. See MASSANIELLO.

ANJENGO, a small seaport town and fortress of Hindostan, in Travancore, nearly encircled by a deep and broad river, at the mouth of which it is situated. The fort was built by the English in 1684, and it was retained till 1813, when the factory was abolished on account of the useless expense attending it. Anjengo is infested with snakes, scorpions, and centipedes; those animals finding shelter in the matted leaves of the cocoa-tree, with which the houses are mostly thatched. Here and at Cochin are manufactured, of the fibres of the Lucadine cocoa-nut, the best coir cables on the Malabar coast. The exports are pepper, coarse piece goods, coir, and some drugs.

ANIMAL. See ANIMAL KINGDOM.

ANIMAL-FLOWER, a name applied to certain species of the genus *Actinia*, remarkable for the brilliant colours which ornament their tentacula, and which produce an appearance resembling the variegated corolla of a plant. The name is of vicious construction, and is falling into disuse. See ZOOPHYTES.

ANIMAL KINGDOM.

WE embrace the earliest opportunity afforded by our alphabetical arrangement to present a few introductory observations in illustration of a science unrivalled in interest, and not greatly surpassed in importance by any department of human knowledge. ZOOLOGY, or the science which treats of the nature and history of animals (from ζῶον, *an animal*, and λόγος, *a discourse*), embraces so vast a field of observation, that although it cannot be regarded otherwise than as a single and beautifully connected science, its great extent of general doctrine, and multiplied variety of details, render necessary a subdivision into many branches, each of which, if worthily followed, is in truth more than sufficient to occupy the undivided attention of the most zealous votary. If in voluminous works exclusively devoted to natural history a single department of the science usually engrosses the entire attention of an author, it is evident that, in the present publication, it would not only be in vain to attempt a complete exposition of the subject under a single head, but that even the various treatises under which its different branches will be exhibited must be presented in a very abridged and compendious form. It shall be our endeavour, however, in the course of our natural history treatises, so to select and methodize the great leading facts of the science, as to enable our readers to form an accurate idea of the present state of zoological knowledge, even though certain minuter details, hitherto forming too conspicuous a feature of the subject, yet not essential to its truthful representation, should in some measure be curtailed.

With a view to obviate to a certain extent the inconvenience arising from the disconnection of the different parts of the science, which the nature of an alphabetic encyclopædia necessarily occasions, we now propose, under the words *Animal Kingdom*, to give, 1*st*, an exposition of such of the general doctrines of zoology as, not pertaining more to one department than another, may with the greater propriety be separated from the history of particular classes, and presented as a useful and appropriate introduction to the whole,—thus uniting the advantages of an alphabetical and systematic arrangement; 2*dly*, to present outlines of some of the prevailing systems of zoology, so as to exhibit in a condensed form the general principles of classification, and enable the student more clearly to understand the relative connections which exist between the scattered treatises in which the subjects (in their alphabetical order) will be afterwards more fully developed; and 3*dly*, to give a sketch of the arrangement to be followed during the future progress of this work, which will not only serve as a guide or general index to the separate articles, but will, on the completion of the Encyclopædia, enable the attentive reader to methodize these articles in such a manner as to form a complete and consistent system of zoology.

It is by no means so easy as it may at first appear, to define precisely what is meant by the term *animal*, because, as we descend in the scale of beings, we find a transition so gradual from those whose powers and properties are strongly characterized, to others which, along with a scarcely perceptible share of sensation and voluntary motion, partake so greatly of the nature of plants, that the most acute naturalists have varied in opinion regarding the exact line of their demarcation. There are also many plants which appear to differ less from certain animals than they do from other plants of an opposite nature and construction. This connected series of organized bodies, however, is not graduated after the mode established by some vague writers on natural history;

for it is not the most perfectly composed, but rather the least complex plants, which follow the most simply organized animals. It has been said that nature follows a continuous and ascending chain, from the mineral to the plant, and from the vegetable to the animal kingdom, the apex of which is crowned by the most perfect work of creation,—the human race. Certain minerals, such as amianthus or asbestos, no doubt exhibit a fibrous or woody structure; and coral, which has a stony texture, a vegetable form, and polypus inhabitants, has been adduced in illustration of the union of the three kingdoms.[1] But all such fanciful speculations are the result of partial and inaccurate observation. The calcareous basis of the coral is formed by a species of polypus, and has no more principle of increase in itself than the shell of the oyster or the waxen cells of the honey-bee. Its elegant branches are created by the instinctive labours of the animal inhabitants, which alone are possessed of life. The animal and vegetable kingdoms are more correctly compared to two great pyramids, intimately united at their bases, but diverging more and more as they ascend.

The extraordinary beings which by their ambiguous nature may be said to have thus blended two kingdoms into one, are called zoophytes or animal plants. They were arranged by Tournefort among vegetables, and were at an after-period removed to the class to which they really belong, chiefly on the authority and through the labours of Linnæus and Pallas. These naturalists bore in mind what few of their predecessors seem to have remembered, that locomotion, that is to say, the movement of a body from place to place *en masse*, though a general characteristic, is not an essential or indispensable attribute, of animality; for numerous animals of the molluscous and radiated kinds are as permanently fixed to their native rocks and coral reefs as the most deeply rooted plants are to the soil which gave them birth.

As sensation and the power of voluntary movement, in whole or in part, are the principal characteristics of animals, it is evident that the more these faculties become developed, the greater will be their removal from the vegetable kingdom. The more perfect the plant, and the more complicated the animal becomes, the greater disparity will be perceived to exist between them. If, in distinguishing the animal from the vegetable, nothing more were required than to point out the differences between an oak and an elephant, the line of demarcation would be easily drawn, and the characters of the respective classes could never more be confounded. But there are many plants which, though less aspiring than the oak, lay claim to a closer alliance to a higher kingdom; and many animals of a more carnivorous nature than the elephant are much more nearly connected by their nature and attributes with the vegetable tribes. When we perceive a living or animalized substance producing by suckers, buds, or offsets from its own body,—when we see that by the influence of light, air, and humidity, it is rendered capable of re-assuming the functions of vitality after a long period of suspended animation and apparent death,—when we ascertain that it cannot live except in water, or when saturated with moisture,—and that although it may be capable of certain languid and partial motions, it is yet fixed for life to a single point of space, where it derives its nourishment by means of external pores,—we have certainly the description of an animal of the lowest order, which applies at the same time almost equally well to vegetable life.

The following were the dicta of Linnæus in relation to the three kingdoms of nature:—"Minerals grow; vegetables grow and live; animals grow, live, and feel." The only character common to these kingdoms, according to the above definitions, is that of growth, or the power of adding to previous bulk. "The vegetation of stones," it is observed by the late bishop of Llandaff, in his *Chemical Essays*, "hath been admitted by many; and some have contended that minerals, as well as animals and vegetables, *spring from seed*, the greatest being nothing but the expansion of the parts of a minute grain of sand." But mineral bodies in truth cannot be said to grow. They receive by aggregation or superposition, by mechanical or chemical agency, an increase of particles. Tournefort, indeed, was of opinion that stalactites in caves actually increased by an internal growth or propulsion like that of plants and animals. But it is known that these concretions add to their bulk by successive depositions of stony particles contained in the water which bathes their sides or percolates through the canal by which their centres are frequently perforated. They possess no attribute which bears the slightest affinity to that internal life which propels the fluids or assimilates the nutritive juices in the animal and vegetable kingdoms. Minerals, then, are destitute of that active power by which animals and plants effect an individual appropriation of such materials as conduce to their nourishment and increase, and which is carried on, not by casual juxtaposition, or the addition of similar particles previously prepared, but by an admirable and elaborate process, through which the ponderous bullock, with its immense load of fleshy fibre, converts into its own muscular and sanguiferous system the sweet-smelling grass of the meadow; and through which also the size and flavour of our most delicious fruits are often primarily derived, from an addition to their natural soil of substances of a very different and less inviting nature. Romé de Lisle has accurately observed that straight lines and plane surfaces are characteristic of mineral bodies, but that animals and plants are composed of curved lines or rounded surfaces, resulting from that central power of life which dilates the internal organs in all directions, and tends to produce spherical or cylindrical forms. The seeds of plants, the eggs of birds, and the young of all animals, are remarkable for the roundness of their outlines.

The objects of natural history, however, are not now divided into three kingdoms; for the characters which connect together plants and animals on the one hand, and distinguish both of these kingdoms from minerals on the other, are so obvious and strongly marked, that the divisions now established are those of *organic* and *inorganic* bodies; the former including all animals and plants, the latter all mineral substances. The definition of an animal, given by M. Virey, is as follows: *A being, organized, sensible, endowed with voluntary motion, and provided with a central organ of digestion.* And he thus defines a plant: *A body, organized, insensible, not endowed with voluntary motion, nourished by external pores.* To these he adds another character, that the reproductive organs of plants are developed and thrown off every year, whereas those of animals are persistent. It is evident that the last clause of his first definition—that which relates to the central organ of digestion—if rigorously applied, would exclude almost the entire of the infusoria from the animal kingdom.

Perhaps the most efficient mode of distinguishing between animals and plants is by having recourse to a certain range of characters, derived from the study of their

[1] Virey, *Mœurs et Instinct des Animaux.*

internal structure and organic functions: thus the possession of nerves, muscles, and a stomach, with the consequent attributes of *sensation, voluntary motion*, and *digestion*, will be found to separate animals properly so called from all other organized matter. If these leading characters are not common to all animals, they are at least proper to them alone; and if the whole of these characters are not always united in the same animal, we invariably find at least one of the three. Thus certain species of polypus, the sensibility and voluntary movements of which cannot be said decidedly to manifest themselves, are obviously furnished with a digestive cavity or stomach; and many of the infusory animals, of the digestion of which we know nothing, are as perfect in regard to their varied powers of locomotion as any of the higher classes. Numerous zoophytical species, indeed, are of so simple a nature, that in them we cannot perceive either a distinct tissue or a nourishing fluid; but we can form some opinion of the nature of their elements from the character of their properties. Irritability indicates nerves, motion supposes the existence of muscles, and the continued maintenance of life attests nutrition. Thus the materials of animal life, so vaguely constituted in these creatures, are detected by their general properties.

In relation to their chemical characters, animals may be said to be principally composed of azote; and vegetables, with the exception of cruciferæ, of carbon. Animals absorb oxygen, plants disengage it; the former reject carbon, the latter become impregnated with it. An exchange of principles is thus effected between the two great divisions of organized existence; but it has been observed that plants merely fix or organize carbon, whereas animals appear to transform into azote, both the air which they respire, and the aliments by which they are nourished.

It has been asserted that a *single mouth*, or opening to the digestive canal, sufficiently characterizes animals from plants, as the latter always possess innumerable pores, which with them are the representatives of the mouth, and conduce to the same ends; but this distinction is in fact inaccurate, as some species of Fasciola possess two mouths, certain Tristomæ three, and the genus called by Cuvier Rhisostoma many more; to say nothing of the infusorial tribes, most of which have no mouth at all, but derive their nourishment by imbibition through the medium of external pores. Nutrition, or the power of deriving nourishment from other bodies, is common alike to plants and animals, and effects for organized and living bodies that increase of bulk which inorganic or disorganized substances can only attain through the medium of an affinity of particles, or by mechanical aggregation. The functions of nutrition, however, as manifested in the animal and vegetable kingdoms, are very differently performed in each. Fixed for ever to the soil which gave them birth, plants are rendered incapable of searching after nourishment by a voluntary change of place, but derive their chief support from roots, the pores of which absorb the nutritive portions from the humid soil, and by a uniform and continuous action, which is only interrupted by an absence of the necessary moisture. The generality of animals, on the contrary, being possessed of the power of locomotion, are also endowed with the capacity of transporting with themselves a supply of necessary nourishment; for which purpose they are provided with an internal cavity or stomach, the inward surfaces of which are provided with absorbing pores, which Boerhaave expressively named *internal roots*. "The magnitude of this cavity," observes Cuvier, "in a number of animals, permits them to introduce solid substances into it. It was necessary then that they should have instruments for dividing those substances, and liquors for dissolving them. In a word, with such animals nutrition does not immediately commence upon the absorption of the substances which the soil or the atmosphere furnishes. It is necessarily preceded by a vast number of preparatory operations, the whole of which constitute *digestion*."[1] The motion of the nutritive fluid in plants, from the simplicity of their structure, and the fixity of their position, seems to be preserved by simple external agents. "It appears to proceed upwards by the effect of their spongy or capillary texture; and the evaporation which takes place at their top, and its motion in that direction, is the more rapid in proportion as the evaporation is great. It appears also that the motion of this fluid may even become retrograde, when it ceases to flow in its usual course, or changes into absorption by the coldness and humidity of the atmosphere."[2] In regard to animals, however, the case is different. Being destined continually to change their localities, and to live exposed to a variety of temperatures, they require an active principle within themselves for the conveyance of their nourishing fluid. This fluid is therefore contained in a multiplicity of canals, which are ramified from two trunks, communicating with each other in such a manner that the roots of the one, called the venous system, receive the contents which the other, known as the arterial system, has propelled to the extremity of its branches, and restore them to the centre, from which they are again driven forward. It is this rotation which constitutes what is called the circulation of the blood. It may be regarded as a function of a secondary order proper to animals, but not universal to that kingdom, as it depends in a great measure on the existence of that central organ called the heart, of which some classes are entirely destitute. It is therefore less essential to life than digestion, and not so intimately related to the faculties of sensation and locomotion. In regard to respiration, animals which are unprovided with a regular circulating system respire, like vegetables, over the whole of their surface, or by various vessels which are placed at different points, and convey the air to the interior of their bodies. "No animals," says Cuvier, "respire by a particular organ, except such as have a real circulation; because in them the blood coming from one common source, the heart, to which it constantly returns, the vessels that contain it are so disposed that it cannot arrive at the other parts until it has passed through the lungs. This, however, cannot take place in vegetables, or in those animals in which this fluid is everywhere diffused in a uniform manner, without being contained in vessels." Pulmonary or branchial respiration is therefore an animal function of a third order, invariably connected with circulation, and one degree removed from such faculties as are essential to animal life.

When a vegetable dies of old age, it begins to decay in the centre. We frequently see ancient willow-trees entirely dead, except in a few slender twigs, or in small portions of their superficial bark. An animal, on the contrary, first dies in its extremities and circumference, whilst the heart or central portion continues for a time to perform, however languidly, its accustomed actions.

Among plants both sexes usually occur in the same individual, or even on the same flower; but in a far greater proportion of animals the two sexes are represented by separate individuals. There is indeed no genuine hermaphrodital union among mammiferous animals, birds, reptiles, fishes, cuttle-fish, crustacea, or in-

[1] *Lectures on Comparative Anatomy*, lecture i.

[2] *Ibid.*

sects. Among many molluscous animals, however, such as the oyster and other bivalves, both sexes are found on the same individual, which is consequently sufficient of itself for the purposes of reproduction, and may be regarded as a genuine hermaphrodite. This singular order of things is in fact indispensable to the nature of bivalve testacea, which, being almost entirely deprived of the power of locomotion, and destitute of eyes or other organs by which to distinguish each other, require to possess within themselves the power of reproduction, lest their kind should cease. The species is both represented and continued by a single individual. In the earthworm, again, the same union of the sexes occurs, but modified in such a way that the concurrence of two individuals is required for the continuance of the race, and each acts in relation to the other both as male and female. This is also the case with slugs, and a great proportion of univalve and turbinated shells. Lastly, the zoophytical animals are not distinguished by any sex, but are multiplied by separation or excision of parts of their own bodies.

The law which establishes a perfect distinction and separation of the sexes in animals seems likewise to produce a double and symmetrical structure, and is of great extent in that kingdom; whilst the circular or radiated form more especially distinguishes plants, and is also characteristic of those zoophytical tribes which, both by name and nature, claim an alliance to the vegetable world.

The grain, and the fruit or kernel, may be said to bear the same relation to a vegetable as the egg or the embryo does to an animal,—with this difference to be borne in mind, that the concurrence of the sexes is necessary to the formation of the vegetable egg, whereas in the animal kingdom that circumstance is indispensable only to the fecundation of the pre-existing germ. The perfection of a plant, and the ultimate aim of its existence, if we may use such a phrase to an inanimate structure, consist in the continuance of its kind. In such as are named *annuals* especially, the term of whose existence is limited in many instances to a small portion of the year, the ripening of the seeds is speedily effected, and, after a very brief period, death succeeds "the bright consummate flower." In numerous tribes of insects the same fleeting existence is observable, though the ephemeral nature of these last-named tribes is rather apparent than real, as the wonderful metamorphoses to which they are subjected conceal their identity from the eye of the uninitiated, and greatly interfere with a continuous tracing of the same individual from the egg to the perfect form. For example, many aquatic flies, such as the Ephemeræ and others, whose declared and more obvious existence does not exceed a few hours, have, previous to their assuming the winged state, spent months or even years in the banks of rivers, and beneath the surface of the stream.

Even the mode of reproduction among the lower tribes of the animal kingdom bears some analogy to that of vegetables; and as the vital principle in the smallest branch or portion of a willow-tree is easily continued and increased though separated from the parent stem, so in many zoophytical animals a bud, branch, or other section, removed from the full-grown individual, suffers no injury from such partition, but, on the contrary, acquires almost immediately a complete and independent power of existence within itself, and is ere long capable of exercising or enduring a like division in favour of posterity. Animals as well as plants are liable to be affected by the revolutions of the seasons; for the period of flowering in the one class is answered by the season of love in the other, and the fall of the leaf is only analogous to the periodical renewal of the feathers of birds and the hair of quadrupeds. The platanus quits and renews its superficial bark, while serpents and cray-fish cast off and reproduce their scaly and crustaceous covering. To be produced and nourished, to increase, to engender, and to die, are characters common to every class of organized existence; but animals properly so called are alone endowed with instinct and voluntary motion,—they alone possess nerves, muscles, digestive organs, and blood, with the faculties of perception, &c. consequent on these attributes.

The preceding observations will serve to illustrate the principal relations and analogies which exist between animal and vegetable life. But there are other characters proper to animals, the whole of which, however, are not universally bestowed on that class, of which it will now be proper to say a few words. The substance of which even the most perfect animal is composed may be resolved into four *tissues*,—the *cellular*, the *muscular*, the *fibrous*, and the *medullary*.

The cellular tissue is the most extensively bestowed, and forms, according to an expression of the French physiologists, the *canvass* of all the organs, and of every animal. It is even common to vegetables, and serves at once to compose, to unite, and to separate the organs. Formed of laminæ or plates interlacing each other in every direction, and perforated by small cavities which have intimate communication, it also sometimes presents itself under the form of membranes, which, when they assume a tunnelled or cylindrical shape, are denominated vessels. It is in this tissue that the gelatine accumulates for the formation of the cartilages, and the calcareous salts for that of the bones. It is amongst its meshes that the fat is amassed, the small vessels distributed, and warmth developed. It forms the basis of the organs.

The muscular tissue is composed of fibrin, and its chief property is that of contraction. It forms what are called the fleshy parts of bodies. Bundles of this tissue crossing each other compose the heart, and, under another aspect, form the stomach and intestines. It is the agent of movement.

The medullary or nervous substance is composed of a soft albuminous pulp, and is protected by powerful membranes. It enjoys the admirable faculties of perceiving, comparing, judging, remembering, and willing; it gives to the senses their special properties, to the muscles their moving force, and is the seat of that mysterious union between mind and body through which the intellectual faculties result or become manifested, and the exact nature of which the most acute of metaphysical inquirers, and the most accurate and thoughtful observers of nature, have as yet sought in vain to illustrate. Sensation is the attribute of the nerves.

The fibrous tissue, the most resistant and unfeeling of all, fastens the bones to each other, and connects the bones and the muscles. It forms the ligaments, the tendons, many vessels, and some resisting membranes employed for the protection of the more important organs. In composition it approaches the cellular tissue, but its properties are dissimilar. Its character is resistance.

Each of these tissues is destined to the performance of a special purpose: The cellular organizes, the muscular moves, the nervous perceives, the fibrous attaches and resists; but one and all are under the influence of that nourishing fluid, so different in various animals, known by the name of blood. This fluid is red, circulating, of a high temperature, in animals of the superior classes—that is, the mammalia and birds; less red, colder, and not so charged with oxygen, in fishes and reptiles; colourless, but still circulating, in the mollusca; without either colour or movement in insects; scarcely perceptible in certain worms; and apparently wanting in zoophytes. It is this fluid which animates all the organs, and presides over

every function. Nutrition exhausts its principles, digestion repairs them, respiration elaborates and renders it perfect, and the action of the heart gives it circulation.

All these elements united and variously combined compose the different organs of animated beings, the harmonious action of which organs forms the essence of our wellbeing, physically considered, in the present stage of our existence. The human race possesses the attributes of animal life in common with the brute creation; but we must ever bear about with us a firm conviction that these are "the accidents, not the essentials of our nature;"[1] and that however proper it may be to mention them as the technical statements of physiology, yet that they are totally inadequate to the description of a being who bears about with him the germ of immortal life, and knows that he was created "but a little lower than the angels."

Those persons," says Buffon, "who see, hear, or smell imperfectly, are of no less intellectual capacity than others; an evident proof that in man there is something more than an internal sense. This is the soul of man, which is an independent and superior sense, a lofty and spiritual existence, entirely different in its essence and action from the nature of the external senses."

It is easy to perceive that one set of organs may be so related to another as constantly to require its co-existence. Thus, circumscribed respiratory organs are always accompanied by a heart, which causes the blood to flow through them; and a brain is never found without nerves and muscles, which serve it as faithful ministers and attendants. The brain receives impressions, and is enabled to judge of them through the medium of nervous sensations: this is the first mode of the functions of relation. But the order is inverse so far as relates to the phenomena of the will as connected with the exercise of the voice and the organs of movement. The brain wills or commands, the nerves transmit the order, and the muscles execute it.

There are other co-existences in the animal economy as apparent as those above alluded to, the motives of which are not, however, so easily comprehended. We are still ignorant why the viscus called the liver should always exist where there is a heart; and why all orthopterous insects should have the forehead furnished with a broad plate.

It will readily be conceived that the diversified circumstances of life in the various tribes of animals necessitate an infinite variety of phenomena in their functions and faculties. An animal which respires, and has its dwelling in the waters, can neither feel nor move after the manner of one which breathes in the pure air; and wherever there are branchiæ or gills instead of lungs, we are sure also to find oviparous generation, an incomplete circulation, an absence of voice, and imperfect organs of hearing and of smell. But the existence of lungs alters the relation of the whole of these functions.

The same principle may be applied to the different kinds of aliment. A carnivorous animal is endowed with force and courage: it has a strait stomach, short intestines, and a lank or somewhat slender form. Herbivorous animals, on the contrary, are usually mild and timid, dull in action, of a sluggish nature, and unapt to self-defence: their intestines are spacious, and their external forms more or less massive. "The disposition of the alimentary canal determines, in a manner perfectly absolute, the kind of food by which the animal is nourished; but if the animal did not possess, in its senses and organs of motion, the means of distinguishing the kinds of aliment suited to its nature, it is obvious that it could not exist. An animal, therefore, which can only digest flesh, must, to preserve its species, have the power of discovering its prey, of pursuing it, of seizing it, of overcoming it, and of tearing it in pieces. It is necessary then that this animal should have a penetrating eye, a quick smell, a swift motion, address and strength in the jaws and talons. Agreeably to this necessity, a sharp tooth, fitted for cutting flesh, is never co-existent in the same species with a hoof covered with horn, which can only support the animal, but with which it cannot grasp any thing: hence the law according to which all hoofed animals are herbivorous, and also those still more detailed laws, which are but corollaries of the first, that hoofs indicate molar teeth with flat crowns, a very long alimentary canal, a capacious or multiplied stomach, and several other relations of the same kind."[2] In short, such harmony exists between the different organs, according to the leading forms after which they are modelled, that an experienced anatomist, from an inspection of a very limited portion of a body, can form an accurate opinion regarding the entire characters of an animal. It is thus that Cuvier, combining profound knowledge of detail with a commanding power of generalization, has, as it were, called back into existence those long-extinguished races whose scattered and imperfect remains attest the wonderful revolutions to which our planet has of old been subjected.

The aid which natural history has derived from the sister sciences of anatomy and physiology, is in nothing more apparent than in the improved systems of modern classification. It was formerly the practice to adopt, as the basis of arrangement, the modifications of some single organ, chosen arbitrarily and at hazard. Of course it did not follow that all the other organs would resemble each other in all the animals in which the likeness of this one organ might be preserved. Nothing, therefore, could be affirmed respecting the other organs belonging to the whole of a class or genus of animals, which we should have attempted to distinguish by characters taken from this unimportant organ. "Suppose, for example," says Cuvier, "that we had made three divisions of animals, the aerial, terrestrial, and aquatic, as they were anciently classed; there would be included in the first class, besides what are commonly called birds, some mammiferous animals, such as bats—some reptiles, as the dragon—some fishes, as the flying fish—and an infinite multitude of insects. Similar difficulties would occur, in a greater or less degree, in the other two classes." "This example is well calculated to show how important it is that the characters of our divisions should be well chosen; for, though in the formation of methods and systems of natural history, errors so flagrant as the above are not now committed, several naturalists, even in modern times, have adopted divisions which, in the detail, tend to similar results."[3]

It is both interesting and important to trace the different systems of organs in the animal kingdom, from their first feeble rudiments, through a gradual and long-continued chain of increasing manifestation, to their complete development in some particular class or order, in which the perfect exercise of a special function is indispensable to its wellbeing. It is in accordance with such development that the improved classifications of recent times have been established; and it is now admitted as an axiom, that a natural and philosophical arrangement of animals can have no other foundation than a knowledge more or less perfect of anatomical structure. It does not follow from this that every naturalist must be a profound

[1] Grinfield's *Letters to Laurence.* [2] *Lectures on Comparative Anatomy*, vol. i. p. 56. [3] *Loc. cit.* p. 62.

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anatomist; for such is the multiplicity of details connected with the history of the haunts and habits of species, and with the discrimination and description of their external characters, which in truth form the proper object of the zoological inquirer, that a much longer period than that allotted to the life of man would be required likewise to ascertain the distinctions of internal structure, were it necessary to apply anatomical science to all the minor details, or even to the less important divisions, of natural history. But the beauty and excellence of the anatomical system consists in the admirable co-ordination of characters which it exhibits, and through which, with rare exceptions, we are able to arrange the subjects of investigation in a natural manner, even according to their external aspect, as soon as we have established certain great leading principles of classification drawn from the facts of anatomical science. The more essential and important characters even of internal structure are manifested externally by the influence which they exert over more obvious though less dominating attributes; and thus, even in the absence of a positive and direct knowledge of general laws, these are indicated with wonderful certainty, though somewhat empirically, by means of superficial observation. It is thus that, through the combined efforts of the naturalist and anatomist, the convenience and facility of application which characterize artificial systems, and constitute indeed their sole value, may be combined with that philosophical accuracy and consonance with the march of nature which results from deeper and more substantial views.

The object of every good method, according to Cuvier, is to reduce a science to its simplest terms, by reducing the propositions it comprehends to the greatest degree of generality of which they are susceptible. A good system must therefore be such as will enable us to assign to each class, and to each of its subdivisions, some qualities common to the greater part of the organs. This object is to be attained by two different means, which may serve to prove or verify one another. "The first, and that to which all men will naturally have recourse, is to proceed from the observation of species to uniting them in genera, and to collecting them into a superior order, according as we find ourselves conducted to that classification by a view of the whole of their attributes. The second, and that which the greater part of modern naturalists have employed, is to fix beforehand upon certain bases of division agreeably to which beings, when observed, are arranged in their proper places. The first method cannot mislead us, but it is applicable only to those beings of which we have a perfect knowledge; the second is more generally practised, but it is subject to error. When the bases that have been adopted remain consistent with the combinations which observation discovers, and when the same foundations are again pointed out by the results deduced from observation, the two means are then in unison, and we may be certain that the method is good."

The true distinction between the value of an artificial and of a natural method in zoology consists in this, that the former teaches us little more than the name of an animal, whereas, in relation to the other, we have no sooner ascertained the name of a species, or its position in the system, than we become at the same time acquainted with numerous facts in its character and history, which we never could have discovered, except by actual observation, had it formed part of those miscellaneous and falsely connected groups which so often constitute the divisions of an artificial system. A natural arrangement is also of great advantage in facilitating general views, by rendering a single animal a type or representative of many, as containing in itself the essential characters of a numerous tribe; and thus the whole animal kingdom may be represented by a few hundred species. By a too strict adherence, however, to the natural method, we are apt to lose the advantage of precision in individual definitions, and, in the case of the numerous transitions, find ourselves unable to fix any limits, if these have not been already established by nature. To discover a medium between these two methods, so as to unite the advantages of each, is now more than ever desirable in the formation of systems.[1] He indeed who flatters himself with the idea that the families, tribes, genera, and sections, which he has laid down on paper, are so many natural divisions, can only be compared to the person who, because he may find the meridians and other circles of an armillary sphere convenient for the division of the heavens, should therefore imagine that they must exist in nature. "In one and the other case," Mr Macleay observes, "artificial modes of distribution are resorted to, which, however ingenious in themselves, are but sad proofs of the limited state of our faculties, when we consider, that without such instruments the vastness and sublimity of the creation cannot be comprehended." (*Horæ Entom.*) There is in fact no such thing as classification in nature. In the animal as well as in the vegetable kingdom certain species are grouped together by such analogies of form and structure, as to render their mutual resemblances apparent even to an ordinary observer. To these groups the name of natural families may, without impropriety, be applied; but that no general system of arrangement exists in nature, by which the various genera may be made to follow each other, like the links of a linear chain, is evident from the discordant, ever-varying, and frequently arbitrary methods employed even by the most accomplished naturalists of the day. We must probably rest satisfied with such a system as presents the objects of natural history in conveniently arranged groups, the component parts of each of which bear a considerable resemblance to each other, without seeking after what is unattainable, namely, the establishment among these groups of a perfectly natural and well-graduated sequence. "When there are," says Mr Vigors, "no absolute divisions except species in nature—and this, from every observation I have been enabled to make, I firmly believe to be the case—every division which we are forced to institute in our arrangements for the convenience of illustration, and indeed for the purpose of mutual communication with those who are engaged in similar researches with ourselves, must be to a certain extent arbitrary and artificial; and every inquirer into nature may cause the line of demarcation that separates his conterminous groups to infringe more or less on the limits of either, according to his peculiar mode of viewing his subject."[2]

No satisfactory argument can be adduced to prove, as some have imagined, that the specific differences of animals have resulted from the lapse of time, and the effects of climate, or other secondary causes. The variation of specific character, though sometimes remarkable, is restricted; and Cuvier has shown, from a minute examination and comparison of mummies of the ancient Egyptian Ibis with individuals of the modern race, that in regard to that species no perceptible change has taken place during the last three or four thousand years. The original creation of distinct and predetermined species is the rational and well-founded belief of all who have studied the

[1] See Carus's *Introduction to Comp. Anat.* translated by Gore.

[2] *Linnæan Transactions*, vol. xiv. p. 512.

subject with attention, unbiassed by any prejudice in favour of imaginative views, which have no foundation in the facts of nature. "It is certain by revelation," says Buffon, "that all creatures have equally participated in the favours of creation; that the first two of each species were formed by the hands of the Creator; and we ought to believe that they were then nearly such as they appear at present in their descendants. We must also consider, that although nature proceeds by gradual, and frequently by imperceptible degrees, the intervals are not always the same. The more exalted the species, the fewer they are in number; and the shades by which they are separated are more conspicuous. The smaller species, on the contrary, are very numerous, and have more affinity to each other, so that we are the more tempted to confound them together in the same family. But we should not forget that these families are our own works; that we have made them for the ease of our memories; and that if we cannot comprehend the real relations of all beings, it is ourselves, not nature, that are in fault; for she in truth knows not our pretended families, and recognises individuals alone."

Omnipotence, the first, the greatest, and indeed the only truly creative power, formed the species of animals; and the influence of man and of physical agents has produced the varieties. But it is only superficial characters which either the one or the other of these ulterior causes has the power of modifying. The basis of organization, or real specific mould, remains unalterable, though a thousand circumstances constantly tend to produce variations in the external forms. Of these circumstances the most powerful is no doubt climate; under which name it is necessary to comprehend the differences of local situation and temperature, the nature of the soil and its productions. It is climate, in the first place, which chiefly determines the geographical position of animals, and thus commences the action of the modifying powers. The nature of their food is also highly influential; and as it depends so immediately on the qualities of temperature and soil, the climate is still the modifying cause. If the same animals usually accompany the same vegetables, it is because the constitution of both demands similar influences, and because through each other they are both dependent upon the same support. Certain animals are leagued with certain plants, and these again with certain soils and climates; and a careful observance of these mutual dependencies exhibits one of the finest and most beautiful harmonies of nature. This, however, is not the place in which to discuss the intricate and important subject of the geographical distribution of animals.

Certain original forms have been continued since the creation of organized beings, and all the *individuals* which represent or belong to one of these forms constitute what is called a *species*. The slighter differences which occasionally prevail among the individuals themselves, independent of the customary distinctions of age and sex, are called *varieties*. Such varieties are seldom permanent, and are usually lost by the progeny re-assuming the ordinary and characteristic form or colour, except in some remarkable instances, such as the horse, dog, and other long-domesticated species, of which man has so thoroughly altered the original condition, as to have impressed them with a second and more pliant nature. An individual, according to Buffon, is a separate detached being, and has nothing in common with other beings, excepting that it resembles, or rather differs from them. All similar individuals which exist on the earth are considered as composing the species of those individuals. Yet it is neither the number nor collection of similar individuals which constitutes them; for a being which existed for ever would not be a species. "Species then is an abstract and general term, the meaning of which can only be determined by considering nature in the succession of time, and in the constant destruction and renewal of beings;" and it is by comparing the present state of nature with the past, and actual individuals with their predecessors in kind, that we come to attain a clear idea of what is called species; for a comparison of the number or resemblance of individuals is only an accessory idea, and frequently independent of the first. The ass resembles the horse more than the barbet the greyhound; yet the latter are but one species, since they produce a fertile progeny; but the horse and the ass are certainly of different species, "since they produce together vicious and unfertile young."

It is indeed difficult to define the term *species*, otherwise than as an assemblage of individuals descended from common parents, which bear as great a resemblance to them as they do to each other. Species then are distinguished by fixed forms, which, though to a certain extent alterable, and for a limited time, by external or accidental causes, are yet handed down unimpaired from generation to generation; and although certain species seem to have disappeared entirely from the earth, in consequence of the great natural catastrophes which have taken place in ancient times, and the local distribution of many still existing races has been modified or changed by the influence of man no less than by the accidents of nature, there is no reason to believe that any one species has sprung from the gradual alteration of another, or that the circumstances under which an individual may have been at first casually placed were sufficient to develope both form and function, without an impress from a higher and more powerful hand, by which it was fitted to perform its part (pre-ordained) in the great theatre of the world.

Animals which by their union produce *fertile* individuals, are generally reputed of the same species. This law of nature, as it was formerly called, having been found to admit of certain though rare exceptions, is not now so broadly insisted on as a test of specific identity as it was in preceding times. But it appears, from the result of numerous experiments, that the generality of animals produced from a cross between even the most nearly allied species, are either altogether incapable of reproduction, or fertile in so imperfect a degree, that their descendants speedily become entirely sterile. It has been said that birds alone were unsubjected to this rule, and that hence has arisen the wonderful variety which that beautiful class exhibits. There is no doubt of the occasional fertility of their hybrids, as in the case of those mule birds produced between the goldfinch and canary; but as it has not been proved that such unions of distinct kinds ever take place when uncontrolled by the depraving influence of domestication, there is no reason to attribute the origin of any of those species or varieties which are known to exist in a wild state to any such improbable alliance.

It is known that a productive union may take place between animals of a different species, provided such species belong to what naturalists call the same natural family. Thus the ass and the mare, or the horse and the female ass, produce the well-known animals called mules: the zebra also produces both with the horse and the ass; but in order to deceive the female zebra, it is said to be necessary to paint the hides of the former with those bizarre colours which adorn her accustomed mate.[1] It is probable,

[1] *Dict. Class. d'Hist. Nat.* tome i. p. 48.

however, that all these unions are so far forced and unnatural, that they never take place except through the influence of man, when domestication, and the numerous changes consequent upon it, have altered or impaired their natural instincts; for it has been observed that, however education may perfect certain special qualities, which man has the art to render subservient to his own convenience, yet a more extended view of the effects of domestication will convince us, that it is almost always to the disadvantage of their natural capacities that the brute creation are made to borrow the mask of human intelligence.

Buffon appears to have adopted from Ray a rule which many now regard as inaccurate and artificial, but which he made use of to determine the identity of animal species, viz. "any two animals that can procreate together, and whose issue can also procreate, are specifically the same." In this, however, it has been observed that he contradicts himself by afterwards admitting that the sheep and goat are of different species, at the same time that he asserts that the he-goat and the ewe produce a mixed breed which continue fertile for ever. Dr John Hunter (a great authority) was also of opinion that the true distinction between different species of animals must ultimately be gathered from their incapacity of propagating with each other an offspring capable of again continuing the kind. Thus the horse and ass beget a mule capable of copulation, but incapable of begetting or producing offspring. The accident of a mule breeding, according to the same authority, even if it were proved, would only show that as many perfect animals of true species and distinct sexes are incapable of breeding at all,—(thus showing that nature, even in her greatest perfection, sometimes deviates from general principles),—so it may occasionally happen that a mule shall breed from the circumstance of its being "a monster respecting mules."

The doctrine of equivocal generation has received no support from any recent investigations. All that is *known* decidedly leads to the opposite conclusion; and if certain mysterious or unaccountable phenomena have perplexed the physiologist, the only legitimate deduction is, that he has met with something which he cannot comprehend; for those aberrations (if such they really are) from the usual laws of nature are not so much exceptions to the general rule, as additional instances of effects in nature, the regulating causes of which we are as yet incapable of demonstrating. The rules of philosophizing lead us to reject the admission of more causes than are sufficient for the explanation of phenomena; and if, for example, mites, and "such small deer," derived their origin solely from the caseous and other substances in which they are generally found, the sexual distinctions which prevail among other animals would in them be unnecessary, and would not therefore be observable. But we know that distinct sexes do exist among these minute creatures—that they propagate their kinds after the accustomed mode—and we hence fairly infer that fortuitous generation does not take place among them. May we not therefore conclude that the origin of those first observed is similar to that of the thousands which we afterwards *see produced* according to the usual process? Nature does nothing in vain, and it is not consonant with her usual practice to suppose that she would authorize two distinct modes of creation in the same animal, where one of these is evidently perfect and self-sufficing. It may therefore be laid down as a general rule, that all living beings proceed from others of a similar nature, either by generation, offset, or some other means; and that, in all instances of apparently spontaneous production, there has existed some minute or imperceptible germs, which deceive us by their sudden development when placed under favourable circumstances. "In fact," says Cuvier, "however feeble and minute the parts of an embryo or the seed of a plant may be at the moment we are first capable of perceiving them, they then enjoy a real life, and possess the germ of all the phenomena which that life may afterwards develope. These observations, extended to all the classes of living bodies, lead to this general fact, that there are none of those bodies which have not heretofore formed part of a body similar to itself, from which it has been detached." "It is from them (their parents) they have received the vital impulse; and hence it is evident that, in the actual state of things, life proceeds only from life, and that there exists no other, except that which has been transmitted from one living body to another by an uninterrupted succession." "Origin by generation, growth by nutrition, termination by death, are the general and common characteristics of all organized beings.[1]"

At the same time it must be admitted, that the origin of many infusory and intestinal animals is sufficiently obscure. Of the latter class, one of the most extraordinary is a monstrous worm, as it may be called, which at distant intervals, and in parts of the world far removed from each other, has been found to inhabit the liver of the human race. The means by which it is bred, or the circumstances favourable to its production, are quite unknown; and some of the most philosophical inquirers of the present day have been unable to account for its origin, otherwise than by supposing that the viscus called the liver becomes, under certain circumstances, endowed with the power of actually secreting a substance capable of assuming and presenting the phenomena of distinct animal existence, and which, prior to the period of its being observed, had in fact become a specific animal;—at least its existence, unlike that of mites, flies, &c. which so often misled the ancient naturalists (though "*in* limo non *ex* limo" is Ovid's more accurate expression), cannot be accounted for in any other way. "There are," Mr W. S. Macleay observes, in his excellent and ingenious *Horæ Entomologicæ*, "many circumstances which might be adduced to support the belief that, whether from disease or other causes, there are periods when other parts of a body besides the ovarium may produce living germs, and demonstrate thus the polype nature of the cellular substance."

A polypus has been sometimes described as an animalized tube, capable of digestion, and possessed of a certain power of motion and reproduction; and these few words may be said to contain almost all that we know of its essential nature and attributes. As we advance in the scale of creation, we find a more complicated system of organs, with more varied powers of action, and a higher development of those accommodating instincts which, though circumscribed within certain impassable boundaries, yet seem at times to form such an approach to reason, as to connect the unvarying mechanical actions of the most simple zoophytical tribes with the conscious self-regulating power which has its final and most perfect development in the human race. The excellence of man, however, physically considered, consists more in the balance of various powers than in any one bodily superiority; for there is in fact no single sense in which he is not excelled by one or other of the brute creation. Materialists, who regard the intellectual superiority of man as the result of his physical structure, must also, for the sake of consistency, maintain his excellence as a machine to be infinitely be-

[1] *Lectures on Comp. Anat.* vol. i.

fore that of every other animal. But as his indubitable superiority depends on something totally immaterial, which "throws him out of the group of animals, and makes him an insulated being," there is the less necessity for either naturalists or metaphysical inquirers endeavouring to demonstrate the superexcellence of his physical condition. Man is in all cases "wonderfully," and in many cases "fearfully made;" but in the powers of sight, touch, hearing, and smell, he is greatly surpassed by many animals; and even in the sense of taste, in which his practice is more varied and extensive, he is at least equalled by the great majority. It is indeed somewhat remarkable that the last-named sense, the only one in regard to which the human race can lay claim to the possession of equal excellence with the brutes that perish, should be the grossest and least intellectual of the whole.

Although it is by no means strictly true that the brain, considered in relation to the size of the body, decreases as we descend from man to the lower tribes, because in many small birds, such as sparrows and finches, the brain is relatively much larger than in the human race, yet, exclusive of some such exceptions, it may be asserted that that important organ becomes less as we descend from mammiferous animals and birds, to reptiles, fishes, and other lower forms. Yet no very accurate conclusion can be deduced regarding the degrees of intelligence in different animals, from the proportion which the quantity of brain bears to the mass of the whole body, particularly when we come to compare animals of the same class with each other. It is in fact by no means easy to ascertain with accuracy what that proportion really is, because the weight of the brain is supposed to remain the same, while that of the animal varies according to its temporary condition. In this way only can we account for the contradictions which appear in the tabular views which have been given of these proportions by physiologists. Upon the whole, the smaller animals pertaining to the higher classes appear to have proportionally the largest brain, though man is in this respect seldom surpassed. The proportional weight of the brain to the body of man varies from 1-22d to 1-35th part, that of the gibbon or long-armed ape is as 1 to 40, that of the young malbrouk (*Simia Faunus*) as 1 to 24, that of the fox as 1 to 205, that of the beaver as 1 to 290, that of the field-mouse as 1 to 31, that of the elephant as 1 to 500, that of the horse as 1 to 400, that of the eagle as 1 to 160, that of the sparrow as 1 to 25, that of the canary-bird as 1 to 14, that of the cock as 1 to 25, that of the goose as 1 to 360, that of the land-tortoise as 1 to 2240, and that of the sea-tortoise as 1 to 5688.

Soemmering, Ebell, Vicq-d'Azir, Gall, and Tiedemann, supposed that every thing depended on the *volume* of the brain. But as Buffon and Daubenton had proved that the Sapajous have the brain proportionally larger than man, without surpassing their congeners in intelligence, it has been maintained by others that the volume alone was not a condition of superiority. Now the Sapajous in question have no *convolutions* to the brain, so that the surface of that organ is represented by that of the interior of the cranium, and exceeds it in other cases in proportion as its folds are numerous and profound; and as there appears to be a constant relation among mammiferous animals between the diminution of the cerebral surfaces and their intellectual degradation, whilst no such relation can be traced between the degrees of degradation and the variations of the brain in respect to size, it has hence been inferred by some that the extent of surface, and not the volume of the brain, ought to be regarded as co-relative with the intellectual faculties.[1]

In proportion, however, as the superior portion called the brain decreases in size, the medullary matter appears to collect in other parts of the body, or in the cords which emanate from the brain; so that many animals with much smaller brains have nerves more voluminous in proportion to their bodies than those of man. This medullary substance, the medium of sensation, is, in the human race especially, collected into one principal mass as the engine of thought and reflection, the intellectual attributes by which man is characterized; but it becomes dispersed in the inferior animals, or ramified over the whole body in the form of ganglions or nervous chords, without any preponderating superior brain. It is owing to this dispersion of the nervous system into these small separate centres in the polypus and other tribes, that almost every portion of the body, when separated from the rest, is capable of becoming a distinct animal, and of assuming an independent existence. In the lowest tribes of all, in which the nervous system has not yet been demonstrated, it probably consists of molecules of inconceivable minuteness, disseminated through the pulpy or gelatinous masses of which the bodies of many radiated and infusory animals are composed.

Singular effects result from the dispersion of the brain into so many small and separate centres; and this class of phenomena also illustrates the analogy which exists between the lower animals and the vegetable world. Among the superior creatures no reproduction takes place except of the fluids, and of whatever partakes of the nature of the epidermis. Injury is repaired and superficial parts renewed, but nothing resembling regeneration of important organs ever takes place. But it is otherwise with the inferior orders. The tentacula of the polypus and of many molluscous animals, the rays of the star-fish, the external members of the salamander, and the entire head, with the eyes and antennæ of the snail, when cut off, are speedily renewed. There are also animals, such as the planaria, which reproduce by offsets after the manner of plants; and a polypus may be divided into many portions, each of which becomes perfect according to its kind;—thus in a manner realizing what the ancient poets have feigned regarding the hydra of the Lernean marshes.

If the head of a mammiferous quadruped, or of a bird, is cut off, the consequences are of course fatal. But the most dreadful wounds that imagination can figure or cruelty inflict have scarcely any destructive influence on the vital functions of many of the inferior creatures. Riboud stuck different beetles through with pins, and cut and lacerated others in the severest manner, without greatly accelerating death. Leeuwenhoeck had a mite which lived eleven weeks transfixed on a point for microscopical investigation. Vaillant caught a locust at the Cape of Good Hope, and after excavating the intestines, he filled the abdomen with cotton, and stuck a stout pin through the thorax, yet the feet and antennæ were in full play after the lapse of five months. In the beginning of November, Redi opened the scull of a land-tortoise, and removed the entire brain. A fleshy integument was observed to form over the opening, and the animal lived for six months. Spallanzani cut the heart out of three newts, which immediately took to flight, leapt, swam, and executed their usual functions for 48 hours. M. Virey informs us, "Nous avons vu une salamandre vivant depuis deux mois, quoique décapitée au moyen d'une ligature serrée du cou." A decapitated beetle will advance over a table, and recognise

[1] See Desmoulins, *Rech. Anat. et Phys.*, and the *Journ. Compt. du Dict. des Sciences Med.* Septembre 1822.

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a precipice on approaching the edge. Redi cut off the head of a tortoise, which survived 18 days. Colonel Pringle decapitated several libellulæ or dragonflies, one of which afterwards lived for four months, and another for six; and, which seems rather odd, he could never keep alive those with their heads on above a few days.[1]

Some curious particulars connected with the great tenacity of life in the lower animals are mentioned by Mr Fothergill.[2] A friend being employed one day in the pursuit of insects, caught a large yellow dragonfly (*Libellula varia*), and had actually fastened it down in his insect box, by thrusting a pin through the thorax, before he perceived that the voracious creature held a small fly, which still struggled for liberty, in its jaws. The dragonfly continued devouring its victim with great deliberation, and without expressing either pain or constraint, and seemed totally unconscious of being pinned down to the cork, till its prey was devoured, after which it made several desperate efforts to regain its liberty. A common flesh-fly was then presented to it, when it immediately became quiet, and ate the fly with greediness: when its repast was over it renewed its efforts to escape. This fact being mentioned to Mr Haworth, the well-known English entomologist, he confirmed the truth of the remarkable insensibility to pain manifested by insects, by narrating an additional circumstance. Being in a garden with a friend who firmly believed in the delicate susceptibility of these creatures, he struck down a large dragonfly, and in so doing unfortunately severed its long abdomen from the rest of the body. He caught a small fly, which he presented to the mutilated insect, by which it was instantly seized and devoured; and a second was treated in the same manner. Mr Haworth then contrived to form a false abdomen, by means of a slender portion of a geranium; and after this operation was performed the dragonfly devoured another small insect as greedily as before. When set at liberty, it flew away with as much apparent glee as if it had received no injury. It is a fact well known to practical entomologists, that large moths found asleep during the daytime may be pinned to the trunks of trees without their appearing to suffer such a degree of pain as even to awake them. It is only on the approach of the evening twilight that they seek to free themselves from what they must no doubt regard as an inconvenient situation.

The cruelty of zoological, especially of entomological pursuits, has too often been stated as an objection to the practical parts of the study of natural history. When a noble aristocrat (who thinks it sport to shoot a shepherd's dog) slaughters 100 brace of grouse in a single day, we hear nothing of such an objection, possibly because the flavour of moor-game is very exquisite; and the reason of defence is good. But the tastes of men differ, and fortunately, as all have not the means of an equal gratification from the same source. "Cruelty," say Messrs Kirby and Spence, "is an unnecessary infliction of suffering, when a person is fond of torturing or destroying God's creatures from mere wantonness, with no useful end in view; or when, if their death be useful and lawful, he has recourse to circuitous modes of killing them, where direct ones would answer equally well. This is cruelty, and this with you we abominate; but not the infliction of death when a just occasion calls for it. They who see no cruelty in the sports of the field, as they are called, can never, of course, consistently allege such a charge against the entomologist; the tortures of wounded birds, of fish that swallow the hook and break the line, or of the hunted hare, being beyond comparison greater than those of insects destroyed in the usual mode. With respect to utility, the sportsman, who, though he adds indeed to the general stock of food, makes amusement his primary object, must surely yield the palm to the entomologist, who adds to the general stock of mental food, often supplies hints for useful improvement in the arts and sciences, and the objects of whose pursuit, unlike that of the former, are preserved, and may be applied to use for many years. But in the view of those even who think inhumanity chargeable upon the sportsman, it will be easy to place considerations which may secure the entomologist from such reproof. It is well known, that in proportion as we descend in the scale of being, the sensibility of the objects that constitute it diminishes. The tortoise walks about after losing its head; and the polypus, so far from being injured by the application of the knife, thereby acquires an extension of existence. Insensibility almost equally great may be found in the insect world. This, indeed, might be inferred *a priori*, since providence seems to have been more prodigal of insect life than of that of any other order of creatures, animalcula perhaps alone excepted. No part of the creation is exposed to the attack of so many enemies, or subject to so many disasters; so that the few individuals of each kind which enrich the valued museum of the entomologist, many of which are dearer to him than gold or gems, are snatched from the ravenous maw of some bird or fish, or rapacious insect, would have been driven by the winds into the waters and drowned, or trodden under foot by man or beasts; for it is not easy in some parts of the year to set foot to the ground without crushing these minute animals; and thus also, instead of being buried in oblivion, they have a kind of immortality conferred upon them. Can it be believed that the beneficent Creator, whose tender mercies are over all his works, would expose these helpless beings to such innumerable enemies and injuries, were they endued with the same sense of pain and irritability of nerve with the higher orders of animals?"[3] Instead, therefore, of believing, and being grieved by the belief, that the insect we tread upon,

> In corporal sufferance finds a pang as great
> As when a giant dies,

the very converse is nearer the truth. "Had a giant lost an arm or a leg," continue the authors just quoted, "or were a sword or spear run through his body, he would feel no great inclination for running about, dancing, or eating. Yet a tipula will leave half its legs in the hands of an unlucky boy who has endeavoured to catch it, and will fly here and there with as much agility and unconcern as if nothing had happened to it; and an insect impaled upon a pin will often devour its prey with as much avidity as when at liberty. Were a giant eviscerated, his body divided in the middle, or his head cut off, it would be all over with him; he would move no more; he would be dead to the calls of hunger, or the emotions of fear, anger, or love. Not so our insects: I have seen the common cockchafer walk about with apparent indifference after some bird had nearly emptied its body of its viscera; a humble bee will eat honey with greediness though deprived of its abdomen; and I myself lately saw an ant, which had been brought out of the nest by its comrades, walk when deprived of its head. The head of a wasp will attempt to bite after it is separated from the rest of the body; and the abdomen, under similar circumstances, if the finger be moved to it, will attempt to sting." Query, which part felt conscious of being the original wasp?

That the acuteness of bodily suffering, even among the

[1] See the observations prefixed to the translation of *Spallanzani's Tracts*, by John Graham Dalyell, Esq.
[2] *Essay on Natural History.*
[3] Introduction to *Entomology*, vol. i. p. 56.

higher classes of the brute creation, is in some manner providentially subdued, and rendered so much less acute as not to be a fit subject of comparison with the suffering of the human race, is indeed evident from various phenomena, whatever the cause may be. The writer of this article has seen a turtle-dove (*Columba risoria*) which was so severely lacerated by a cat, that the contents of its stomach were torn out. The painfully excited sympathy of those who had long cherished the gentle creature was, however, in a great measure allayed by seeing the bird immediately afterwards proceed to pick up the fresh grains of barley which (till the aid of the surgeon was called in) continued to fall from its wounded haunch.

Considerations of the nature glanced at in the preceding paragraphs can never, of course, be so misconstrued as to afford any palliation to wanton or inconsiderate cruelty to the brute creation. The judges of the Areopagus who condemned to death the child whose amusement it had been to pluck out the eyes of quails, were regulated in their determination by the motives imputed to the young criminal, and which they deemed expressive of so cruel and pernicious a character, that in after-times he would assuredly offend the state. "Nec mihi videntur Areopagitæ," says Quintilian, "cum damnaverunt puerum coturnicum oculos eruentem, aliud judicasse, quam id signum esse perniciosissimæ mentis, multisque malo futuræ, si adolevisset."[1] But had some great oculist, intent on the structure and physiology of the human eye, and engaged in a difficult course of experimental observation, by means of which the "dim suffusion" which often veils the orbs of his fellow-men might be obviated or decreased, found himself under the necessity of having recourse to a somewhat similar operation, the case would have assumed another character, and the most sentimental philanthropist must have applauded the practice of the philosopher. So it is in a great measure with the pursuits of the naturalist. If the wonderful structure of the lower orders of creation cannot be studied or understood, or their infinitely varied forms held in remembrance, without hastening by a few days or hours the termination of that brief career which in truth scarcely ever meets with a strictly natural end, then is the student of nature, following out the principles of an elevating and intellectual pursuit, as well entitled to command a portion of animal life as he who, to pamper the refined grossness of a sensual appetite, bleeds his turkeys to death by cutting the roots of their tongues, boils crabs and lobsters alive, and swallows unsuspecting oysters by the score.

The more perfect the nervous system, the greater is the degree of intelligence. Indeed, were it not that no trace of that system has yet been discovered in many zoophytes, we might almost assert that the presence of nerves constitutes animal life, and that their absence in organized matter reduces it to the vegetable state. The greater the extent of brain in proportion to the size of the body, the greater in general the degree of sensibility. A French anatomist, in dissecting a horse of which he had admired the noble qualities, exclaimed, "J'ai long temps douté si nous avions le droit de monter sur ton dos; mais en voyant la petite capacité de ton cerveau, je n'en doute plus maintenant; tu n'est qu'une bête." The most perfect animals are such as are provided with a head which serves as the centre of their sentiments and sensations, and with a mouth for the reception of their nourishment. Their forms are symmetrical, or composed of two equal parts; they change their place by a voluntary act; their sexes are distinct, and separately incapable of continuing the species; they are provided with five senses, and endowed with the perception of pleasure and of pain. The inferior tribes, on the contrary, which present so many analogies to the vegetable kingdom, have no distinct head, or single organ of life; they are not symmetrical or composed exactly of two equal parts, but rather affect the circular or radiated form; and for the most part they either remain fixed to the place which gave them birth, or with difficulty change their places of abode. The sexes are frequently united in the same individual, and their senses are limited to such as are necessary to a very confined and almost vegetative existence.

Though no animal has more than five senses, a great many are much more sparingly endowed. The only universal sense seems that of touch. The next to be developed is probably that of taste, then sight, hearing, and, lastly, smell. In the human race the senses are more equally balanced than in the brute creation, among the different tribes of which we find many animals as remarkable for their extreme acuteness in certain senses, as for their obtuseness in respect to others. The sense of smell in the dog, excepting some artificial varieties, such as the greyhound, prevails over every other; birds of prey are remarkable for their keenness of sight; the sense of hearing is strong in the hare; that of touch in the trunk of the elephant; that of taste in the lord of the creation. It follows as a consequence that the dog is by nature a hunting animal; that the eagle, upborne upon resplendent wing, describes its magnificent circles in the air, "sagacious of its quarry from afar;" that the hare couches securely among the long dewy grass, with its head so low that its eyes must be almost useless, but trusting to its quicker ears, which warn it of an approaching foe; that the elephant examines the exact nature of all objects by touching them with the fleshy finger of its proboscis; and that Mrs Rundell's work on cookery has run through nineteen editions. All insects in the perfect state, and the greater proportion of their larvæ, a part only of the molluscous tribes (such as the inhabitants of univalve shells), crustaceous animals, such as crabs and lobsters, and all fishes, reptiles, birds, and quadrupeds, enjoy the sense of sight; and all these classes (with the exception of insects and many of the mollusca) are also furnished with the organs of hearing. That the latter sense, however, also exists in insects, may be fairly inferred from the frequent and varied sounds which they are capable of producing, although the seat of the faculty has not yet been ascertained. Many zoophytical tribes, which have no special organs of sight, appear to become sensible to the presence and action of light, through a delicate perception of the sense of touch. According to Buffon, the sense which has the strongest affinity to thought is that of touch; and he regards it as being enjoyed by man in greater perfection than by animals. That which has the strongest affinity to instinct and appetite is smell,—a sense in which man must acknowledge an infinite inferiority. Hence, according to the Frenchman, man has the greatest tendency to knowledge, and the brute to appetite. There is no doubt that in man and the different species of monkeys the sense of touch is highly discriminating; but it is assuredly a false view of the subject which has led Helvetius and others to attach such an extraordinary degree of importance to the *hand*, as the medium of intellectual superiority in the human race.

Whatever exhibits the phenomena of either animal or

[1] *De Inst. Orat.* lib. v. cap. ix. *de Signis.*

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vegetable life, advances towards the perfect development of its parts through the medium of aliment. This name is applied to the numerous and diversified substances which, when introduced into the system of an organized body, have the power of identifying themselves in part with that system, in such a manner as to effect its nourishment, reparation, and increase. "Nourishment," says Bacon, "ought to bee of an inferior nature and more simple substance than the thing nourished. Plants are nourished with the earth and water, living creatures with plants, man with living creatures. There are also certain creatures feeding upon flesh; and man himself takes plants into a part of his nourishment: but man and creatures feeding upon flesh are scarcely nourished with plants alone. Perhaps fruits or graines, baked or boyled, may with long use nourish them, but leaves of plants or herbs will not doe it; as the order of the *Foliatanes* showed by experience living creatures are nourished by the mouth; plants by the root; young ones in the womb by the navill; birds for a while are nourished with the yolke in the egge, whereof some is found in their crops after they are hatched. All nourishment moveth from the centre to the circumference, or from the inward to the outward: yet it is to be noted, that in trees and plants the nourishment passeth rather by the barke and outward parts than by the pith and inward parts; for if the barke be pilled off, though but for a small bredth round, they live no more: and the blood in the veines of living creatures doth no lesse nourish the flesh beneath it than the flesh above it. Vegetables assimilate their nourishment simply without excerning; for gums and teares of trees are rather exuberances than excrements; and knots or knobs are nothing but diseases. But the substance of living creatures is more perceptible of the like; and therefore it is conjoyned with a kinde of disdaine, whereby it rejecteth the bad and assimilateth the good. It is a strange thing of the *stalkes* of fruits, that all the nourishment which produceth sometimes such great fruits should be forced to passe thorow so narrow necks, for the fruit is never joyn'd to the stock without some stalkes. It is to be noted, that the seeds of living creatures will not be fruitful but when they are new; but the seeds of plants will be fruitful a long time after they are gathered; yet the slips or cions of trees will not grow unlesse they be grafted green, neither will the roots keepe long fresh unlesse they be covered with earth."[1]

Nutritive substances of course vary according to the nature of the bodies which consume or absorb them. Plants derive their chief nourishment from air and water, the former of which must contain carbonic acid gas, the latter the dissolved remains of animal or vegetable substances. It is, however, possible to produce vegetable growth from pure water, assisted by warmth and air. Vegetables, again, serve as food to the greater proportion of animals, and these in their turn are devoured by the carnivorous few. It is thus that the productions of nature are connected together in one great circle, and are reciprocally dependent on each other. Without water there could be neither plants nor herbivorous animals, and without herbivorous animals there could be no carnivorous ones; therefore, without water there could be no life. Inorganic matter furnishes the first and most simple materials of existence; organic bodies perish and become decomposed, and thus adding to the mass of inorganic matter which they had for a short period abandoned, they enter again as elements into the composition of other and more complex forms. Indeed, according to Mr W. S. Macleay, organized matter is nothing but a peculiar modification of brute matter acted upon by the vital principle; but this form of expression probably throws no new light upon the subject.

We may here present a remark not unworthy of attention regarding the nature of the flesh in the different classes of the animal kingdom. Considered as a viand, the flesh of animals becomes less substantially nourishing as we descend in the scale. For example, the flesh of a quadruped contains a greater quantity of nourishment in proportion to size and weight than that of a bird, while the latter exceeds in that respect both reptiles and fishes. Hence in catholic countries the latter are justly regarded as *meagre*, and form an exclusive food during the frequent days of abstinence by which it is sought to mortify the flesh. Shell-fish and crustacea, and *a fortiori* the zoophytical tribes, yield a still smaller proportion of nutritious matter. A revolting conclusion has been drawn from this alleged relation between the flesh of a highly organized animal and the power and excellence of its nutritive qualities; viz. that cannibalism, or the habit of anthropophagous nations, opens up to those unnatural tribes a pleasure connected with the indulgence of the sense of taste greatly surpassing what is enjoyed by those who confine their mastication to the brute creation; because, in accordance with the rule supposed, the organic perfection and highly animalized nature of man is productive of a higher degree of nutrition, and of a greater capability of direct assimilation, when the substance of which he is composed is used as food by his fellow-mortals. But the scale of alimentary substances may rather be said to commence with air and water, and to terminate with the herbivorous animals; for the flesh of carnivorous kinds is, with very few exceptions, of a nature inadequate to the healthy sustenance of life. It is of a quality too putrescent, and decomposes with too great rapidity, as if the organization of matter could make no further progress, but passing rapidly from one extreme to another, hastened to throw off even the semblance of life, to assume again the simplest elementary form. "Over-great affinity," says Bacon, "or consubstantiality of the nourishment to the thing nourished, proveth not well; for creatures feeding upon herbs touch no flesh; and of creatures feeding upon flesh few of them eat their owne kinde. As for men which are cannibals, they feed not ordinarily upon men's flesh, but reserve it as a dainty either to serve their revenge upon their enemies, or to satisfie their appetite at some times. So the ground is best sowne with seed growing elsewhere; and men do not use to graft or innoculate upon the same stocke."

Mineral bodies are still more unfit for the purposes of nutrition. They furnish both medicines and poisons in abundance, but never aliments. The difference between these objects may be shortly stated as follows: Aliments are substances alterable by the action of the organs which appropriate them; medicines act on the organs, of which they alter or modify the action; poisons attack and extinguish life itself. But according to the specific nature of different animals, and various other circumstances, the qualities of these agents are convertible, so that aliments become poisonous, and poisons alimentary. Thus opium, which among European nations is a medicine, and too frequently a poison, has become, according to the practice of several eastern nations, an alimentary substance. Aloes, which are simply medicinal for the human race, are a destructive poison to many carnivorous animals. On the other hand, according to Pallas, hedgehogs eat abundantly of cantharides without being in the slightest degree incommoded by them; and bees are known to feed

[1] *History, Naturall and Experimental, of Life and Death.* English translation, 1638.

pon and form their honey from the secretions of many ernicious and even poisonous plants. The caterpillar of certain sphinx moth is highly delighted with the acrid nd venomous fluid of a tithymalis.

The more that animals enjoy the qualities of youth, trength, and activity, the greater is the increase and de- elopment of their parts, and the greater the necessity for n abundant supply of food. Of many individuals exposed an absolute abstinence of many days, the young are lways the first to perish. Of this the history of war and hipwreck offers in all ages too many frightful examples. here are several instances on record of an almost total bstinence from food for an extraordinary length of time. aptain Bligh, of the Bounty, sailed nearly 4000 miles in n open boat, with occasionally a single small bird not any ounces in weight for the daily sustenance of 17 eople; and it is even alleged, that 14 men and women of e Juno, having suffered shipwreck on the coast of Arra- an, lived 23 days without any food. Two people first ied of want on the fifth day. In the opinion of Rhedi, nimals support want much longer than is generally be- eved. A civet cat lived 10 days without food, an ante- pe 20, and a very large wild cat also 20; an eagle sur- ived 28 days, a badger one month, and several dogs 36 ays. In the memoirs of the Academy of Sciences there an account of a bitch, which having been accidentally ut up alone in a country-house, existed for 40 days ithout any other nourishment than the stuff on the wool f a mattress which she had torn to pieces. A crocodile ill live two months without food, a scorpion three, a bear x, a chameleon eight, and a viper ten. Vaillant had a spider at lived nearly a year without food, and was so far from eing weakened by abstinence, that it immediately killed nother large spider, equally vigorous but not so hungry, hich was put in along with it. John Hunter inclosed a ad between two stone flower-pots, and found it as lively s ever after 14 months. Land-tortoises have lived with- ut food for 18 months; and Baker is known to have kept a eetle in a state of total abstinence for three years. It af- rwards made its escape.[1] Dr Shaw gives an account of vo serpents which lived in a bottle without any food for ve years.

The necessity of aliment becomes less vividly felt du- ng sleep, and certain other periods of prolonged repose. here are several animals which hybernate, or go into win- r quarters for six months in the year, during which period any of them require no food, but are maintained solely y that excellence of bodily condition which they had ac- uired during a prior period of activity and good cheer. his leads us naturally to consider what is called the *hy- rnation* of animals.

Many creatures are so constituted that the activity of eir functions is greatly impaired by a comparatively ight reduction of temperature. Naturalists and anato- ists have alike sought in vain for either external or in- rnal characters of general application, by which they ight distinguish, *a priori*, the species subjected to this range though well-ordered lethargy. They belong to rious genera and tribes, many of which have few cha- cters in common, as will be perceived when we name well-known instances the dormouse, the hedgehog, d the bat. It influences both warm and cold-blooded imals. The former of these, at certain advanced periods the autumn, according to the species, seek out places repose, either in the earth, among old walls, in caverns, unks of trees, or bushes; which retreats they usually e with dried herbs, grasses, leaves, or moss. The bat ooses caverns, churches, barns, and other situations where the temperature is milder than that of the open air; and, contrary to the usual practice, it suspends it- self by the hooked claws of its hinder extremities. It is the practice of other hybernating animals to contract themselves into a ball, in such a manner as to expose the smallest possible surface to the action of the air. When discovered in their retreats they are generally thus rolled up, cold to the touch, their limbs stiffened, their eyes closed, their respiration slow, interrupted, sometimes even imperceptible, and their insensibility so great that they may be removed, rolled about, and otherwise maltreated, without showing any further signs of life.

It has been observed that the temperature of these ani- mals gradually lowers itself as the season declines. Their respiration also becomes slower, their motions less lively, and their appetite diminishes; but sensation and the power of locomotion still continue. This intermediate state between the perfect performance of the vital func- tions and confirmed torpidity endures for several weeks; the degree of temperature at which different animals be- come entirely overpowered varying, of course, according to the species. The propensity has been observed, in the following well-known animals, to correspond to a scale of descending temperature, according to the following or- der:—1*st*, The bat; 2*dly*, the hedgehog; 3*dly*, the dor- mouse; 4*thly*, the marmot; 5*thly*, the hamster. Although many other animals are subject to the same law, it is only among those just enumerated that an exact comparison has been instituted.

A complete state of hybernation consists in the sus- pension of sensation and voluntary motion, in addition to a great decrease in the temperature of the body, and in the frequency of respiration. Its different degrees of in- tensity are well ascertained by the number of respirations in a given time, or, in its most perfect state, by the total suspension of all respiratory movements. The different species of the bat tribe are those of which the torpidity is the least profound; and the marmot probably experiences the greatest degree of vital suspension. The temperature of these animals during their lethargy depends in a great measure upon that of the external air, and is consequent- ly variable. It is in general, however, superior to it by several degrees. It may descend to within a few degrees of the freezing point, but is not susceptible of reduction to that point, without producing either re-action of the vital functions or death. There is, therefore, contrary to the opinion of some of the older naturalists, a degree of external cold incompatible with the torpidity or existence of these animals. The species most easily rendered torpid, such as the bat, the hedgehog, the dormouse, the lerot, and the muscardine, cannot support a cold of 14° of Fahrenheit. A warmth of from 50° to 53° brings them again to life. Sundry mechanical means, such as different degrees of motion, serve to restore several of the last-named species without any increase of temperature; but to preserve them in a state of prolonged activity, a gentle warmth must be applied and continued.

It is evident, from these and other observations, that the sleep of mammiferous animals is not characterized by a uniform and constant duration. As it is dependent on the variations of the atmosphere, it will commence at an earlier, continue a longer, or be interrupted after a shorter period, according to the difference in the seasons of par- ticular years, the skill which the animals may have exhibit- ed in the choice of a protecting habitation, or the pecu- liar constitution of the species, or even of the individuals. The habit of storing up a supply of winter provisions also depends upon their greater or less degree of exposure to

[1] See the observations prefixed to the translation of *Spallanzani's Tracts*, before referred to.

the power of awakening influences. The hedgehog, for example, has been observed to form several separate magazines, to which it has recourse during the winter season; and the marks of its little feet have sometimes been traced on the surface of the surrounding snow.

The hybernation of the swallow is a point on which very dissimilar opinions have been promulgated. It now appears to be the prevailing belief that these birds migrate on the approach of winter to other and more genial climes, but that cases do occur in which such individuals as are prevented by circumstances from joining the "marshalled array," are enabled to survive the rigours of our northern winters by the power which their constitution possesses of assuming the torpid state; at least the occurrence of torpid swallows, however rare, is too well authenticated to be a matter of doubt.

It is said that the tanrec, a species of hedgehog found in Madagascar, becomes torpid for some months in the year. If this assertion is well founded, it affords the only known instance of torpidity in a mammiferous quadruped of a warm climate.

Many cold-blooded animals may be regarded as of the hybernating kind. Indeed the greater proportion of reptiles, insects, molluscous animals, &c. inhabiting cold countries, are very lethargic during the winter season, which they usually pass without food. They appear subject to the influence of this feeling even in warm climates; at least Humboldt describes certain reptiles in South America which pass a portion of the year buried in the earth, and which are only aroused by the occurrence of rainy weather or the excitement of violent means. "The manners of animals," says this enlightened observer, "vary in the same species, according to local circumstances difficult to investigate. We were shown a hut, or rather a kind of shed, in which our host of Calabozo, Don Miguel Cousin, had witnessed a very extraordinary scene. Sleeping with one of his friends on a bench covered with leather, Don Miguel was awakened early in the morning by violent shakes and a horrible noise. Clods of earth were thrown into the middle of the hut. Presently a young crocodile, two or three feet long, issued from under the bed, darted at a dog that lay on the threshold of the door, and, missing him in the impetuosity of his spring, ran toward the beach to attain the river. On examining the spot where the barbacon or bedstead was placed, the cause of this strange adventure was easily discovered. The ground was disturbed to a considerable depth. It was dried mud, that had covered the crocodile in that state of lethargy, or summer sleep, in which many of the species lie, during the absence of the rains, amid the llanos. The noise of men and horses, perhaps the smell of the dog, had awakened the crocodile. The hut being placed at the edge of the pool, and inundated during part of the year, the crocodile had no doubt entered, at the time of the inundation of the savannahs, by the same opening by which Mr Pozo saw it go out. The Indians often find enormous boas, which they call *uji*, or water-serpents, in the same lethargic state. To re-animate them, they must be irritated, or wetted with water."[1]

Upon the whole, naturalists seem to be of opinion that no species of animal is condemned to torpidity by any inherent property of its nature. It is a provisional faculty, dependent on external circumstances, and may be interrupted, postponed, or altogether prevented, by regulating the conditions under which the animal is placed.

The disposition of animals in relation to other individuals of the same species differs considerably. There are some which unite in couples and divide between them the cares of the family. This is usually the case among the various tribes of birds, and also among carnivorous quadrupeds; whilst the males of such as feed on vegetables, and which consequently find almost everywhere an abundant and easy nourishment, abandon to the mother the rearing and education of their young. It has also been observed, that among such birds as feed on living prey, the male is very assiduous in assisting his mate to procure a sufficient supply. But naturalists have erred in assigning the polygamous habit as a general characteristic of the gallinaceous kinds. The instinct to pair, or the habit of monogamy, is no doubt only bestowed on those species to which it is necessary for the rearing of their offspring, and differs considerably in the nature and permanence of the attachment, according to the position of the nest, *i. e.* whether it is built upon or above the surface of the ground. All birds which build on trees, as was long ago remarked by Lord Kames, are hatched blind, and almost without feathers, and consequently require the sedulous care of both parents. But the generality even of gallinaceous birds, which breed upon the ground, do likewise pair, though the hatching of the eggs is entirely confined to the female, who completes her task by leading the young to their proper food, which they are able immediately to pick up for themselves, being active and well feathered from their birth. The male, at the same time, continues to manifest a certain degree of paternal solicitude, by uttering the alarm-note on the approach of birds of prey, or other dangerous foes. Black game and wood-grouse, however, do not appear to pair at all; but in the spring a male bird assembles a certain number of females about him, which afterwards deposit their eggs, and rear their young altogether independent of the male parent. They are therefore polygamous in the proper acceptation of the term. Even among herbivorous quadrupeds pairing is rare, because the female can suckle her young while she herself is feeding; but the monogamous habit probably obtains among most carnivorous quadrupeds, and certainly among all carnivorous birds, because incubation leaves the female no sufficient time to hunt for food,[2] and because young birds cannot bear a long fast, and therefore require the assistance of both parents, while unable to provide for themselves. The association or fellowship of birds is either annual or for life; the former bond is the more usual, though eagles, crows, and several other species afford examples of a long-continued attachment.

Many birds assemble in autumn, winter, and early spring, into flocks, but as soon as the pairing season has commenced they again separate into pairs. Others again appear to be more gregarious during the breeding season than at any other period of the year, for example the gannet or soland-goose (*P. bassanus*); but this arises not so much from a love of fellowship with their kind, as from the accident of there being few places fitted for the purposes of nidification and the rearing of the young.

We have said that pairing is rare among such quadrupeds as feed on grass, because the female can feed herself at the same time that she is suckling her young. The roe-deer, however, among herbivorous quadrupeds, forms an exception to the general rule. On the other hand, there are several carnivorous quadrupeds which do not pair, but the young of which are left entirely dependent on the mother; that is to say, the latter is obliged both to capture her own food and to suckle her offspring.

Among gregarious quadrupeds which usually store up food for winter, pairing is probably necessary to prevent discord, and in this respect beavers are said to resemble those birds which place their nests upon the ground. As

[1] *Personal Narrative*, vol. iv. p. 380.

[2] See Kames's *Sketches*.

soon as the young are produced, the males abandon their stock of food to their mates, and live at large, but return frequently to visit them while they are suckling their young. Hedgehogs and most of the monkey kind pair. Seals are polygamous, and turtles leave their young to be hatched by the heated sand. Earwigs, spiders, bees, and woodlice (*onisci*), are amongst the few of the insect tribes which pay any attention either to their eggs or offspring. The young of the greater proportion of animals is produced in spring, when the supply of food is the most abundant, and when the long period which intervenes before the approach of winter enables them to acquire strength to support the rigours of that inclement season.

Though the period of gestation varies considerably in the different quadrupeds which feed on grass, yet the females are regularly delivered in spring, or early in summer, when the herbage is nutritive and abundant. The mare conceives in summer, carries 11 months, and brings forth in May. The same is nearly the case with the cow. The sheep and the goat are usually in season in November; they carry five months, and produce when grass has begun to spring. They love short, close herbage, upon which a horse or cow would barely thrive. The ass is in season about the beginning of summer, but she bears twelve months, and consequently brings forth likewise early in summer. Wolves and foxes copulate in December, but as they only bear five months, they bring forth in April, when the season has assumed a genial aspect, and animal food is as abundant as at any other season. If we were to guess what would probably be the rutting season of animals, we would say summer, especially in a northern country; and yet, to quadrupeds which carry their young only for four or five months, such economy would be injurious and improvident, as it would bring the time of delivery at an undue season, both for warmth and food.[1] There are a few exceptions to the above rule, which, however, in themselves, belong to an equally beautiful system of providential ordinances. Some gregarious and store-collecting animals, for example, bring forth in January, when their granary of provisions is still abundantly filled.

The season of pairing, or of production, among wild animals, usually takes place only once a year, and at a fixed period; but those which man has rendered domestic are observed to couple at all seasons. The species of warmer climates, when transported into colder regions, usually cease to pair, or at least their union is unproductive; and the same consequence generally follows a state of captivity. Among such species, however, as man has fairly reduced to a state of satisfied domestication, the individuals become much more prolific than in the wild state.

The season of love varies greatly among mammiferous animals. The greater proportion pair in spring and summer; but the wolf pairs in winter, the stag in autumn, and many domesticated animals at diversified periods throughout the year. Prolific union takes place among *varieties* of the same species; and it is by paying attention to these that the finer races of our domestic animals are maintained and continued. As the climate of northern countries causes several of our most valuable animals to degenerate (as it is called), it has been customary to obtain from time to time a male animal of a pure and noble race, which, when paired with an ordinary female, produces a breed scarcely inferior to the male parent; for it has been observed that, with few exceptions, the new produce assumes the characteristics of the father. Thus, in uniting a sheep of an ordinary kind with a ram of the Merino race, the first generation almost equals the father in beauty.

What is frequently called deterioration in animals is, more properly speaking, their natural assumption of those peculiar attributes which fit them for the inclemencies of climates uncongenial to their original nature. A Laplander is no more a deteriorated Asiatic of the Mongolian or Caucasian line, than a Georgian or Circassian is a highly refined Laplander; neither is the Shetland pony a deteriorated Arabian courser, any more than the steed of Araby is a thorough-bred shelty. Each has been enabled by a wise provision of nature to assimilate its character and constitution to the qualities of the climate in which it was destined to exist; and had it been incompetent to effect or undergo such assimilation, it would then indeed have deteriorated—that is to say, it would have died. If we admire the slim smooth elegance of the Italian greyhound, and regard the rough shaggy coat of the dog of Nova-Zembla as a deterioration, let us remember that that which is the beauty of the one would be the bane of the other; and what would then become of that forlorn agriculturist, whose business it is to drill the ice and to furrow the snow? The small stature and peculiar habits of the northern pony would have been as little fitted to sustain the fiery breath or the shifting sands of an eastern desert, as the graceful Arabian to withstand the cold and cloudy clime, and the rugged and precipitous mountains, of Lapland or Thule. Therefore, instead of being deteriorated, each ought rather to be said to exist in the best and most improved condition, according to the nature of its particular calling. Using the word, however, in its more usual acceptation, it may be stated that an animal seldom degenerates in its native country, but more frequently in those for the climate of which its constitution is not adapted. Each species appears to have a certain extent or circle of natural distribution, in the centre of which it not only most abounds, but also there shows itself in its finest and most characteristic proportions. As the places of its occurrence diverge from this centre of dominion, it becomes rarer, and exhibits a variation or considerable departure, at least in its external characters, from the primitive model. Thus the horses of Arabia and Barbary degenerate in Britain; and, to preserve the breed in purity, they must be frequently crossed by the original; but the Arabs themselves are very careful to prevent any mixture in the blood of their native and noble kinds, and would deem them deteriorated by such alliance.

In the tabular or abridged views of classification which we here present, it is our intention merely to exhibit the great primary divisions of the animal kingdom called *classes*. The secondary divisions into orders, and the further dismemberment of these into minor groups called families, genera, &c., will be illustrated when we come to treat of each class in particular under its proper head. Neither do we intend to trace the progress of classification from the earliest ages of scientific record; because, as the object of the naturalist is rather to ascertain the nature and relationship of things as they are, than as they were supposed to be, there is the less necessity for leaving our direct route, to trace either the origin or the progress of error. We shall proceed, after a few observations, at once to the system of Linnæus, which is in fact the basis of all that have succeeded, and without a knowledge of which it is impossible to understand either the merits or defects of more recent systems. Indeed, with the exception of the purely artificial classification of Klein, and the multiplied orders of Brisson and Vicq-d'Azir, all the systems which have appeared since the middle of last century are indebted more or less to the labours of the immortal Swede, and may be valued almost exactly in pro-

[1] Kames's *Sketches*.

portion to their share in the *lucidus ordo* of the Linnæan system. For example, the *Systema Regni Animalis* of Erxleben (1777) is nothing more than a revised edition of the *Systema Naturæ*, in which are engrafted, with no lack of skill, many additions both of species and genera; the whole being presented in a consecutive series, without the accustomed subdivision into the primary groups called *orders*. The *Prodromus Methodi Animalium* of Storr (1780) does not differ radically from the Linnæan system. The *Elenchus Animalium* of Bodaert (1787) is allied to it still more closely in every thing except its accuracy. Of Gmelin's work (1789) we need not speak, as it is a professed revisal (being the 13th) of the *Systema Naturæ*. And although no one will deny the merit of profound and original inquiry to the investigations of Blumenbach, most readily will those who are best acquainted with his labours admit, that in zoology he has wisely followed the footsteps of Linnæus. The six classes into which the German naturalist divides the animated creation, viz. *Mammalia*, *Aves*, *Amphibia*, *Pisces*, *Insecta*, and *Vermes*, correspond with those of the Linnæan arrangement, although their orders and genera are in some respects differently combined. His motto appears to have been *Multa fiunt eadem, sed aliter.* (Quintilian.)

The signal benefits conferred on natural history, in all its branches, by the learning and genius of Baron Cuvier, are known wherever the science has obtained a zealous and successful cultivator; and it cannot have escaped the notice of the critical observer, that after 30 years of profound and philosophical research into the mysteries of the animal kingdom, the most enlightened zoologist of the age should have finally reverted to a closer approximation to the Linnæan system, than had characterized his views at any former period of his brilliant career. When he first made known (in 1797), conjointly with M. Geoffroy, his new classification of mammiferous animals, his numerous genera were contained under no less than 14 different orders. Thirty years afterwards (in 1817) he published his *Règne Animal*, with many improvements in the composition and arrangement of the minor divisions, and with the addition of the order of which he is himself so bright an ornament, but otherwise composed (we speak at present of the mammalia alone) of primary divisions exactly the same in number, and nearly the same in nature, as those finally divulged and established by Linnæus himself just 60 years before.

Latreille, Dumeril, Desmarest, and Frederick Cuvier, are followers or coadjutors of the Baron, and with him are partakers in the modification and amendment of the Linnæan system. The venerable Lamarck has greatly signalized himself in a field which, it must be confessed, was obscure to the eye of Linnæus—that of the molluscous animals—which, under the name of Vermes Testacea, were but indifferently treated in the *Systema Naturæ*. The error appears to have lain in the greater attention which was bestowed on the shells themselves, or testaceous coverings, than on the animal inhabitants; and the consequence has been, that the conchologist of the old school ranks with the collector of china, whether old or new.

The names above enumerated are certainly among the foremost in the annals of modern science; and although, in addition to these, many more might be mentioned with honour as having contributed, by monographs or other partial though highly prized contributions, to the increase of knowledge, yet we are not aware that more than three systematists of acknowledged and wide-spread influence, or of what may be termed universal celebrity, remain unnoticed, of those who have essentially influenced the present condition of zoological science; we mean Fabricius, Illiger, and M. de Blainville. We have no hesitation in asserting, that as the writers first mentioned owe much of the success which has attended their labours to their having judiciously engrafted their own improvements on the original stock of the Linnæan system, so the authors last named, though not less highly gifted, have in a great measure sacrificed the utility of many original and enlightened views to the fond conceit of a new, and in some instances an incomprehensible, nomenclature.

The skill of Fabricius as an entomologist has never been surpassed, and it is therefore the more to be regretted that he should have been influenced in the formation of his system by other motives than a desire to perceive and point out the truth. But it is known that he was swayed as much by the ambitious hope of founding a new doctrine, of which he destined himself to be the oracle, as by the desire of proceeding directly in the path of nature. Hence his avowed enmity to the eclectic system of Latreille, which, during the opening career of that celebrated entomologist, he declared it to be his intention utterly to destroy. Yet the system of Latreille not only stands, but, when viewed in relation to the application of its general principles, has in a great measure superseded that of Fabricius. At the same time, the accurate discrimination and extensive knowledge of the latter, and the wide circle which his system embraces in detail, render it still indispensable for a knowledge of the species.

Illiger died young. His talents were such as to raise among his compatriots the highest hopes of his future eminence, and his death was a subject of just regret to all who knew what he had achieved so well at an early age, and who the more gladly lent themselves to the anticipation of what he would afterwards have accomplished had his life been prolonged. Of his classification it has been written by a competent judge: "Neque apud veterem, neque apud recentiorem quendam auctorem ullum systema invenerim, quod, tam sua perspicuitate, quam accuratione, Illigeriano magis commendari mihi videatur." Many of his genera are indeed remarkable for their felicitous construction and consonance with the natural arrangement. They have in consequence been readily adopted by his more fortunate fellow-labourers in the same field, in whose works they will remain, and be handed down in ample attestation of the author's genius; but the system itself will suffer a partition, and ere long cease to be practically known under the form in which it was originally promulgated, and this mainly in consequence of his having adopted so many new names.

M. de Blainville is still alive, and the longer he lives the better for the sciences of anatomy and physiology, neither of which contains in its modern annals the name of a more accomplished or enlightened expounder of its mysteries than his own; but in the character of a naturalist, and in connection with the subject of nomenclature, he unfortunately sins more than all his predecessors. He really miscalls the objects of zoology most sadly, yet his knowledge of the essential bases of the science is no doubt too profound to admit of his applying it without new and important results. Hence the pity that these should not at all times be stated in such terms as not only to amalgamate more closely with the kindred labours of his contemporaries, but to fall rather more clearly within the comprehension of ordinary minds.

As it is not our intention in the present rapid sketch to enter into the distribution of the animal kingdom beyond the greater divisions called classes, we shall not exhibit the systems of the two first-named authors further than to say, that the former attended almost exclusively to entomology, the latter chiefly to the mammalia and birds. When we come to the divisions of our subject under their separate heads, tabular views or more detailed ana-

lyses will be presented of the labours of these and other ingenious inquirers of the past and present times.

We have said that we regarded the system of Linnæus as the basis of all those by which it has been succeeded, and that without a knowledge of his classification it would be impossible to understand either the merits or defects of more recent systems. We shall therefore here present the classes into which the great Swedish naturalist divides the animal kingdom.

DIVISION I.

A heart with two auricles and two ventricles; blood warm and red.

CLASS I.—Viviparous animals, or such as suckle their young; commonly called quadrupeds, but including also the cetacea or whales, MAMMALIA.

CLASS II.—Oviparous animals, or birds..... AVES.

DIVISION II.

A heart with one auricle and one ventricle; blood cold and red.

CLASS III.—Animals breathing arbitrarily through lungs..... AMPHIBIA.

CLASS IV.—Fishes, or animals with gills... PISCES.

DIVISION III.

A heart with one ventricle, no auricle; blood cold and white.

CLASS V.—With antennæ; undergoing transformations. Insects..... INSECTA.

CLASS VI.—With tentacula, and undergoing no transformations. Worms, VERMES.

It may be observed, that the deservedly popular system of Linnæus, though it does not profess to be a natural method of classification, actually is so in many of its parts; nor can it be denied that, on the whole, it usually brings together as many groups of natural genera as occur in most systems that have been promulgated, especially if we take into consideration the period at which it was composed, and the comparatively scanty materials within his reach. Linnæus was probably aware of the extreme difficulty, we might say at once of the utter impossibility, of a perfectly natural arrangement; for he confesses, in his *Philosophia Botanica*, his inability to define the great divisions called *orders*, on account of their being so connected with each other by various points of affinity, as to form a map rather than a linear series; and the observation may be applied with equal truth to the subjects of the animal kingdom. In regard to the excellence of his genera themselves, their consonance with nature is rendered still more evident, by the great proportion of those which Cuvier and Latreille have retained as leading generic divisions in their recent works,—certainly the most skilful approaches which have yet been made in the establishment of a natural system. It has been asserted, and we believe with truth, that such naturalists as are perpetually intent on the abstract theory of classification, rarely attain the highest excellence in the discrimination or definition of the species,—the only distinctions possibly which have a real foundation in nature, and upon an accurate and extensive knowledge of which alone their theoretical systems can be substantially and permanently built. At all events, it is admitted that Linnæus is a guide almost infallible, in as far as concerns his wonderful facility in discovering the minor natural groups. If he could have combined these as well as he has defined them, his possession of the sceptre would have been still undoubted.[1]

M. Virey, in the first edition (1803) of the *Nouveau Dictionnaire d'Histoire Naturelle*, divides the animal kingdom into three great tribes, in accordance with the nature and distribution of the nervous system. As he appears to have been among the first to attribute a due degree of importance to that system in the classification of animals, we shall here exhibit a view of his general arrangement.

TRIBE VERTEBRATA.

Animals possessed of two nervous systems, the cerebro-spinal and the ganglionic.....	Heart with two ventricles and two auricles; blood warm, lungs cellular.....	Man and Mammalia. Birds.
	Heart with one ventricle and one auricle; blood cold.....	Reptiles and Fishes.

TRIBE INVERTEBRATA.

Animals possessed of a single nervous system surrounding the œsophagus, with ganglia and branches; the *sympathetic*.....	A heart; branchiæ for respiration, mostly aquatic.....	Mollusca. Cirrhipedes. Crustacea.
	No heart; some vessels; tracheæ for air or water.....	Arachnides and Aptera. Insects, winged, hexapod. Annelides and Helminthides. Intestinal worms.

TRIBE ZOOPHYTA.

Nervous system composed of molecules more or less perceptible; no distinction of sexes.....	Ascidia, inclosed in a tunic.....	Botrylli, &c.
	Radiated animals; composed of rays parting from a centre.....	Echinodermata. Hydra and Polypus.
	United in Polypiers, or stony masses; coralligenous.....	Corals and Ceratophytes. Madrepores and Sponges.
	Microscopical.....	Infusory Animals.

The following summary will serve to illustrate M. Virey's views of the nature and characteristics of these three great divisions. We commence with the zoophytical tribe.

1st, *Zoophytes* are distinguished by an organic tissue of a very soft and pulpy nature, more or less diaphanous, and very contractile, though we cannot readily perceive its muscular fibres. Its fundamental character consists in the extreme division of its nervous molecules throughout the flesh of these animals. Except in the Echinodermata and some other radiated classes, we can scarcely assert the existence of a nervous system amongst them (on which account they are named *apathiques* by Lamarck). Each portion of the body having its nervous molecule and its par-

[1] *Horæ Entomologicæ*, part ii. p. 428.

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ticular source of vitality, there is no common centre of sensation; thus division and generation are almost synonymous, and when individual parts are mutilated they are speedily reproduced. With these tribes the production of the species is in fact nothing more than a simple sprouting of a bud or offset, which separates itself from the maternal stalk. Zoophytical animals are of no sex, and thus resemble the agamous vegetables. The mouth is usually placed in the centre of the body, and is frequently surrounded by a species of unarticulated arms, radiating from a centre like the petals of many flowers. Several genera have only a single opening for the reception and rejection of the aliment. They have no viscera (excepting *cæca* in certain species); no heart, nor arterial nor venous vessels; no true circulation; no apparent organs of respiration. They are all aquatic, and water seems indeed the only fluid which pervades their economy. They may be called the cryptogamia of the animal kingdom. The sense of touch, and perhaps that of taste, seem the only ones enjoyed by these animals.

2dly, The *Invertebrata* present a greater complication of organs. Their principal character consists in a nervous system, extending itself, especially in the intestinal cavity, by numerous ramifications. In all the families of this great tribe, the nervous trunks surround the œsophagus, pass beneath the belly, and are furnished with many ganglions which supply branches to the different organs. That which is regarded as the brain in this tribe (named *sensible* by Lamarck) is nothing more than one or two ganglia situated above the œsophagus; but the particular distribution of the two nervous branches which spring from the collar of the gullet, and extend themselves over the body, gives rise to the divisions of *molluscous* and *articulated* animals established by Cuvier.

The last-named naturalist has observed, that in the mollusca the nervous system is composed of many ganglionic masses, dispersed throughout the organization, but connected by means of nervous filaments; and that the chief of these masses constitutes a kind of brain above the œsophagus. The mollusca have no skeleton; their muscles are attached to the skin, a soft contractile envelope, in which in many species are produced shells, or stony bodies of calcareous carbonate, formed by exudation or superimposed concretion. Besides the sense of touch, common to all animals, the mollusca are gifted with that of taste, and sometimes of sight; but the sense of hearing has not been remarked, except among the *Cephalopoda* or cuttle-fish. Their systems of digestion and secretion are rather complex; they are provided with a liver, and possess a circulating or vascular system, through which flows a humour or whitish sanies in place of blood. Their respiration is effected by aquatic or aerial branchiæ. The sexual organs are frequently united in the same individual.

Among the articulated classes (such as the crustacea, the arachnides, and insects) the nervous system consists of a double chord, extending from the head to the posterior extremity, and bearing knots or ganglia which correspond to the segments of the animal's body. The first ganglion above the œsophagus takes the place of what we call the brain in the higher animals, but it is not voluminous in proportion. All these animals are composed of segments or annular divisions, and their forms are elongated, and more or less cylindrical. Their skin or outer covering, always of a somewhat solid texture, becomes in many families hard, corneous, or even stony; and the muscles are attached to its interior. The greater number have articulated members, feet, wings, pincers, palpi, &c. Many of these animals have closed vessels; and the crustacea have a heart and branchiæ. Others, according to Cuvier, are nourished by simple imbibition. Those insects which undergo metamorphoses are furnished with tracheæ or air-vessels for respiration, dispersed over their bodies. The organs of the sense of hearing are not discernible except among the crustacea; taste is universal, and also sight, except among the worms. Their jaws always ply laterally. The sexual organs are usually separate.

3dly, The *Vertebrata* comprehend all those animals which have a nervous system composed of ganglia, called sympathetic, for the functions of the internal life; and another symmetrical nervous system, of which the principal portions are inclosed in the cranium and spinal column, and which sends off chords for the functions of the external life. These are the most perfect and most highly endowed of all animals; they are named *intelligens* by Lamarck, and they are always endowed with five senses, of which never fewer than four are situated in the head. They possess a heart, red blood, a liver, lungs in the species which live in air, and branchiæ in those which live in water. An articulated, bony, symmetrical skeleton, placed in the interior of the body, gives support and solidity to the different parts. Such are man, mammiferous animals, and birds, which have warm blood, and respire by cellular lungs; such also are reptiles and fishes, of which the blood is cold. In all, the mouth has two horizontal jaws, and the members are never more than four in number.

The preceding are M. Virey's views of the distribution and general characteristics of the different classes of the animal kingdom.[1] They contain a sound exposition of several of the substantial relations which exist between the different systems of the animal economy, and we present them to the reader even at the risk of afterwards repeating in part several essentialities of his doctrine, when we come to promulgate the views of his celebrated countryman and contemporary Baron Cuvier.

We shall next present a tabular view of the general distribution and primary divisions of animals according to the system of Lamarck. It will be observed that this author commences with the lowest tribes.

Animals without Vertebræ.

* Apathetic Animals. (*Apathiques.*)

1. Infusoria. 2. Polypi. 3. Radiata. 4. Vermes.	*Characters.* No brain nor elongated medullary mass; no special senses; forms various; rarely articulated.

(*Epizoaria.*)

* * Sensitive Animals. (*Sensibles.*)

5. Insecta. 6. Arachnides. 7. Crustacea. 8. Annelides. 9. Cirrhipedes. 10. Mollusca.	*Characters.* No vertebral column; a brain, and generally an elongated medullary mass; some distinct or special senses; organs of movement attached beneath the skin; formed symmetrically of equal parts.

Animals with Vertebræ.

* * * Intelligent Animals. (*Intelligens.*)

11. Pisces. 12. Reptilia. 13. Aves. 14. Mammalia.	*Characters.* A vertebral column, a brain and spinal marrow; distinct senses; organs of movement attached to parts of an interior skeleton; formed symmetrically of equal parts.

[1] *Mœurs et Instinct des Animaux*, tome i. p. 130.

The author of the preceding arrangement has entered pon the discussion of certain preliminary points connect-d with the subject of classification, which may be regard-d as composing the *art* rather than the *science* of Zoology. Ie inquires (in his introduction to the *Hist. Nat. des nim. sans Vert.*) what are the operations to be perform-d for the execution of a good distribution of animals, and r the establishment of the necessary divisions of that istribution? These operations he states to be as fol-ws: 1*st*, To assemble animals together according to a rinciple which is not arbitrary, and so as to form a gene-l series, whether simple or ramified: 2*dly*, To divide is general series into different kinds of lesser divisions, which the one shall be subordinate to the other; and ith that view to make choice of and submit to certain itable and convenient principles (*principes de conve-nce*): 3*dly*, To fix the rank of each sort of division after e general principle, previously established; as, for ex-nple,

The rank of each primary group in the total series;

That of the classical divisions of each primary group;

That of the orders or families in each class;

That of the genera in each family; and

That of the species in each genus.

The execution of these three sorts of operations is re-rded by Lamarck as indispensable; and that it is so has en long felt by naturalists, almost all of whom have more less occupied themselves in the attempt, but always in arbitrary manner—that is to say, without the previous tablishment of principles deserving of general consent. he first of the operations alluded to—that which con-rns the bringing together of species in such a manner as form a general series—is an essential preparation, which ght to precede the other operations, and without which deed the latter could not be executed. It tends, more-er, to enable us to discover the order of nature, with hich it is so highly important that we should become quainted. Although nature has necessarily followed a rtain order in the formation of organized beings, and pecially of animals, yet as she has now dispersed these imals, and commingled all the different races over the rface of the solid globe, or through the wide depth liquid waters, the original order of formation is to a cer-in extent disfigured, and so far imperceptible. We are erefore obliged, with a view to its ascertainment, to arch after some means by which we may attain to that scovery, and to work out some solid principles to lessen e chance of error. In regard to this, the most impor-nt step has been already attained, when we acknowledge e interest inspired by affinities or relations, and the ne-ssity of understanding these, with a view to submit to em, as to a test, the various parts of our general distri-ution. It may thus be perceived, that in order to esta-ish a good distribution of animals, in such a manner that solidity shall run no risk of being enfeebled by the ar-trary nature of opinion, it is necessary first of all to as-mble our species according to well-determined affinities; ter which we may, without inconvenience, trace out the es of demarcation which separate the groups called asses, and those other subordinate groups of which the tablishment is so advantageous, provided the natural lations are in nowise compromised by their formation. may perhaps be proper shortly to inquire into the na-re of these relations, their different degrees, and the act uses which it becomes us to make of such as we certain and acknowledge. We shall then be enabled th greater facility to determine the principles which it fit to establish.

Relations, according to Lamarck, are those traits of semblance or analogy which nature has bestowed, as well on her different productions when compared among themselves, as on the different parts of those same productions when compared with each other. These traits of resemblance and affinity are so necessary to be known and understood, that no methodical distribution can be established on a sure foundation, if the objects which it embraces are not arranged according to the law which they prescribe. Relations are of different orders, some being very general, others less so, and many altogether special or particular. Moreover, although, in general, relations belong to nature, all are not the direct result of her operations in regard to her productions; for among the relations which we perceive between the compared parts of different beings, there are many which result merely from a modifying cause. Thus the relations of exterior form, which are so apparent between the cetacea and fishes, can only be attributed to a property resulting from the dense medium which each inhabits, and not to any direct plan in the operations of nature in regard to both. It is necessary then carefully to distinguish those obvious and acknowledged relations which pertain to the direct operations of nature in the progressive organization of animal life, from certain others, equally obvious and acknowledged, which result from the influence of local circumstances, or from the peculiar habits which different races have in some instances been forced to acquire.

Relations of the last-named nature, though certainly of greatly inferior value to the former, are by no means limited in their influence and exhibition to external characters alone; for it may be demonstrated that the external cause which possesses the power to modify the direct operations of nature frequently exercises an obvious influence on several internal organs. It becomes the more necessary then to establish certain rules, devoid of arbitrary qualities, to enable us justly to appreciate the nature and value of these relations; and it may be established as a principle in zoology, that it is from the interior organization that the most essential are to be obtained. This principle is well founded if it expresses the pre-eminence which ought to be accorded to general considerations, gathered from the interior organization, over those derived from external parts. But if, instead of using it in this manner, we apply it to particular cases of our own choosing, and without pre-established rule, it is capable of great abuse; and we shall arbitrarily assign to relations presented by such or such system of internal organs, a preference over certain others, although the relations of the latter may in reality be of greater importance. By this means, sufficiently convenient for the changeable views of individual authors, we admit into various parts of our distribution inversions in every way contrary to the order of nature.

It is true, as has been already observed, that a cause which modifies organization not only acts on the exterior parts of animals, but also produces various modifications in their internal structure. It follows, that it is incorrect to suppose that the relations which exist between the races, and especially between the genera, the families, the orders, or even in certain cases the classes of animals, can always be decided merely from the isolated consideration of any internal organ, arbitrarily selected. On the contrary, Lamarck is of opinion that the relations of which we speak cannot be suitably determined except by a consideration and comparison of the whole of the interior organization, and, auxiliarly, by that of certain special internal organs which assured principles have demonstrated to be the most preferable and important.

The second question proposed by M. Lamarck is the following: What are the principles by which we ought to be guided in our operations, so as to exclude from these

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whatever is arbitrary? Our author is of opinion that it is by the precise discrimination of each sort of relationship, and by aid of a determination, substantial and explained, of the preference which ought to be accorded to one kind over another, that we shall discover principles proper to regulate all the parts of our general distribution of animals. It is necessary then to determine the principal kinds of relations which ought to be employed to attain this end, and then to fix the superiority in value which one kind possesses over another. The following is the classification of Lamarck in further illustration of this subject.

* *Relations between Comparative Organizations, deduced from the whole of their parts.*

These relations, though general, manifest themselves in different degrees, according as we seek for them among races compared in themselves, or among groups of animals of different races compared with each other. It is necessary then to distinguish several kinds.

First kind of general relations.—These seem immediately to connect races or species with each other. They are of necessity the first, because it is they which furnish the greatest of the relations between animals which differ from each other. The *zoologist* who determines it, taking into consideration all the parts of organization, as well interior as exterior, admits not of this sort of relation, unless when it presents the smallest and least important difference. We know that animals which resemble each other perfectly, both in their internal and external organization, can be nothing more than individuals of the same species. In this case the relation is not considered, as such animals offer no distinction. But those which present among themselves a difference, tangible, constant, and at the same time the smallest possible, are connected by the greatest and most immediate of relations, if they present elsewhere a great resemblance in all the parts of their interior organization, as well as in the greater proportion of their external features. And this sort of relation does not demand a consideration of the degree of composition or relative perfection of the animal organization, for it determines itself in all the ranks of the scale. It is so easy to seize, that every one acknowledges it at first sight; and it is by employing it that naturalists have formed those smaller portions of the general series called genera, notwithstanding the arbitrary nature of their limits. Thus, in this first kind of relation, which may be called the *relation of species*, the difference between the objects compared is the smallest possible, and need only be sought for in the particularities of form or of the external parts of individuals.

Second kind of general relations.—This embraces the agreements which exist between groups of different animals when compared together. It may be named the *relation of groups;* and, to acquire a knowledge of its nature, we must no longer occupy ourselves essentially with the particulars of the general form, nor with those of the external parts, but almost solely with the interior organization, considered in all its parts. It is this kind chiefly which ought to furnish the differences by which we distinguish the groups from each other; and it is inferior in one or more degrees to the first kind in the quantity of resemblances which exist between the compared objects. It serves to form the *families*, by connecting the genera with each other; to institute the *orders*, or the *sections of the orders*, by uniting several families; and, lastly, it determines the classical groups into which we ought to partition the general series. The relations of which we now speak cannot, however, be employed to determine the *rank* of the great masses of that series, but only to form diverse combinations for establishing and distinguishing these masses.

From the consideration of these relations, the two following principles may be deduced.

First principle.—The general relations of the second kind do not require a perfect resemblance in the interior organization of the compared animals. "Ils exigent seulement que les masses rapprochées se ressemblent plus entr'elles, sous ce point de vue, qu'elles ne le pourraient avec aucune autre." (*Anim. sans Vert.* tome i. p. 355.)

Second principle.—The greater and more general the compared masses, the more will such masses differ in their internal structure. Thus the *families* present a less difference in the interior organization of the animals by which they are constituted, than the *orders* or *classes*.

Third kind of general relations.—We may denominate *relations of rank* those which serve to determine the position in the great series, and which, proceeding from a fixed point of comparison, effectively show among the compared objects a relation, whether great or small, in the composition or perfection of the organization. This kind is obtained by comparing any organization whatever, taken in the totality of its parts, with any other given organization which may be presented as a point of departure or of comparison. It is then determined, by the resemblance, greater or less, which is found between the two compared structures, to what extent that which we compare departs from or approaches to that which is given as a point of comparison. We shall see that this sort of relation is the only one which ought to serve for regulating the rank of all those important primary masses into which we divide the animal kingdom.

If we consider the question concerning the choice of a particular organization, from or towards which to remove or approximate other organizations successively, according to their greater or less resemblance, it becomes evident that the selection ought to fall on one or other extremity of the animal kingdom (as in that case there would be no uncertain balancing), and the best known extremity should have the preference. Thus, in setting out from the most perfect and highly finished structure, we should, in the determination of all the ranks, proceed from the most composite to the most simple, and should close the series by the most imperfect and least organized of the whole.

Of all forms of structure, that of man, considered in its totality, is at once the most composite and complete. From this M. Lamarck concludes that the more any animal organization approaches that of the human race, the more it advances towards comparative perfection and its own completion. This being the case, the organization of man is with that author the point of comparison and departure from which to judge of the relation, whether near or distant, of every form of animal structure, and by which we are to determine the rank which those forms, or the groups which they constitute, ought to occupy in the general series. The organization alluded to, considered in the totality of its parts, furnishes the means by which to judge of the degree of composition and perfection of other animal structures also regarded in their totality. And in doubtful cases it is not difficult to rid ourselves of uncertainty and embarrassment, by having recourse to the fourth kind of relations, or to those principles which concern the comparison of the different organs separately considered, and establish a predominating value and influence among certain of those organs when compared with others. Thus, our point of departure or comparison being found, the rank of all the divisions may be assigned with facility by the aid of the principles which follow.

First principle.—For the determination of the rank of ach mass in the series,—the most complicated and com-lete of animal organizations being selected as the point f comparison,—the more another form of animal struc-ure, considered in the whole of its parts, resembles that f the fore-chosen, the more it will approximate towards by its relations; and reciprocally in the converse cases.

Second principle.—Among the organizations of which he plans are different from that which comprehends the articular structure selected as the point of comparison, hose which offer one or more systems of organs similar r analogous to such as form a portion of that with which hey are compared, shall rank superior to those possessed f a smaller number of these organs, and, *a fortiori*, to those which they are wanting.

With the assistance of the three kinds of relations above ndicated, and the principles deducible from them, M. La-marck regards it as easy to determine the distinctions f species, and those of the various larger groups which pecies form; and to decide, in a manner by no means ar-itrary, the rank and station of each group in the great eries. If this be true, the science will cease to be as va-illating in its onward march as it has hitherto proved.

But our efforts would be incomplete, and would still ave too large a field for the exercise of arbitrary opi-ions, if no attempt were made to establish and define the alue of *particular relations*,—that is to say, of those which re obtained by the comparison of particular internal or-ans, considered in an isolated manner in different animals.

* *Relations between similar or analogous parts taken separately in the organization of different animals, and compared with each other.*

The *fourth kind of general relations* merely embraces articular relations between unmodified parts. It is drawn om the comparison of parts separately considered, and hich, in the system of organization to which they belong, fer no real anomaly. The consideration of this kind is metimes of great consequence in assisting to decide in oubtful cases, when we are anxious to determine, among ertain compared groups, to which the superiority of rank ight to be assigned. Such cases sometimes occur where e whole of the parts of the interior organization present means of deciding, in an unarbitrary manner, to which two organizations the superiority belongs. It is espe-ally in the formation and position of the orders, sections, milies, and even genera, of each class, and consequently the assignment of the rank of all these inferior groups, at the employment of this fourth kind of relations is of lvantage; because, in regard to such groups, the prin-ple of the third sort of relations is frequently very diffi-lt of application; and thus arbitrary modes of arrange-ent are introduced, most baneful to the science, by ex-sing the works of naturalists to a continual variation in e determination of the relations which ought to fix the mposition of the groups, and their order of position. fact, as many animals, really connected by the general aracters of their class, present remarkable differences in ertain of their interior organs, and yet at the same time xhibit equally striking resemblances in others, we feel at, in order to appreciate the degree of importance pos-ssed by the relations which exist between particular or-ans, we must have recourse to certain regulating prin-ples in our determinations, to avoid arbitrary conclusions. he two following principles are proposed by Lamarck, to able us to appreciate the relations observable between articular internal organs in different animals compared ith each other.

First principle.—Between two internal organs, or sys-ms of internal organs, separately considered and compared, that of which nature has made the most general employment ought to have the pre-eminence assigned it in the value of the relations which it presents. According to this principle, the following is the order of importance which we ought to attribute to the particular organs which nature has employed in the interior organization of animals:—

The organs of digestion;	The organs of production;
The organs of respiration;	The organs of sensation;
The organs of movement;	The organs of circulation.

Thus, when we take into view the greatest generality of employment of the particular organs of which nature makes use in the interior organization of animals, we perceive that the organs of digestion occupy the foremost rank,—those of circulation the last. We have thus an order of value or precedence, in regard to these important organs, capable of regulating, in doubtful cases, the preference which one relation merits over another.

Second principle.—Between two different modes of the same organ, or system of organs, that which is most analogous to the mode employed in a superior or more composite and complete organization, merits the preference in the relations which it exhibits. If, for example, we desire to employ a relation afforded by the organs of respiration,—to judge of the preference which it deserves over that offered by other organs,—we are obliged, according to the principle above established, to keep in view the following consideration:—Although the system of organs provided for respiration is very widely employed in the organization of animals, since, with the exception of the polyped and infusorial classes, all the rest possess a respiratory system, yet the mode of that system not being the same in all the classes by which it is exercised, we assign a higher value to the true *lung* than to the *branchia*, to the latter than to the *aeriferous tracheæ*, and to these than to the *aquiferous tracheæ*. According to this view, we may judge whether the mode of respiratory organs of which we wish to employ the relation, is sufficiently high in value to permit our yielding to it a preference over a relation deduced from some other kind of organs.

The *fifth kind of relations* embraces the *particular relations* observable between the modified parts. It requires that, among the parts compared, we should discriminate between that which is due to the real plan of nature, and that which pertains to the modifications which that plan has experienced from accidental causes. Thus this class of relations is derived from parts which, considered separately in different animals, are not in the state in which they ought to be, according to the plan of organization to which they belong. To judge of the degree of importance which ought to be accorded to a relation, and the preference which it deserves over another, it is a matter of no slight consequence to distinguish if the form, the increased or diminished development, or even the entire disappearance of the particular organs under consideration, belongs to the plan of organization of the animals subjected to such modifications; or whether the state of these organs is not rather produced by a modifying and determinable cause, which has altered or annihilated that which nature had executed, and would have maintained, but for the influence of that later cause. "For example," says Lamarck, "it would have been impossible for nature to furnish a head to the *infusoria*, the *polypi*, or the *radiata*, &c.; for the condition of these bodies, and the degree of their organization, did not permit it; and it was only on arriving at the class of insects that a genuine head could be supplied." Now, as nature never retrogrades in her operations, we naturally expect, that when once arrived at the formation of insects, and consequently of *heads*, the recipients of the special senses, all animal organizations

superior in composition to that of insects will also exhibit these organs. This, however, is not universally the case; because no distinct head is observable among the *annelides*, the *cirrhipedes*, and many *mollusca*, all of which are generally regarded as superior to the class of insects. "Une cause étrangère à la nature, en un mot, une cause modifiante et déterminable, s'est donc opposée à ce que les animaux cités soient pourvus d'une véritable tête." (*Anim. sans Vert.* tome i. p. 363.) And that cause appears to have operated sometimes by hindering to a greater or less extent the development of that part of the body, and at other times by effecting its complete destruction. We find the same thing in regard to eyes and teeth, and to various other parts both of the internal and external structure; because a modifying cause has had the power to alter, enlarge, diminish, or even to effect the total disappearance of these organs. We may perceive, then, that the relations obtained from the consideration of changed or modified parts must be of very inferior value to those furnished by the same parts existing in a state conformable to the plan of nature. Hence results the following

Principle.—Whatever nature has directly formed deserves a pre-eminence in value over that produced by a fortuitous cause, which has modified the work of nature; and in the choice of a relation to be employed, we should assign the preference to every organ, or system of organs, which we find existing as it ought to do according to the plan of organization of which it forms a part, over that organ, or that system of organs, of which either the condition or existence has resulted from a modifying cause, extraneous to original nature.

When two different organs, between which a choice is to be made, are both found to be changed or altered by a modifying cause, the preference should be given to that which is least removed by such a modification from the condition in which it would have existed according to the plan of organization of which it formed a part.

The *third question* proposed by M. Lamarck is as follows:—What disposition or mode of arrangement should be given to the general distribution of animals, so as to render it conformable to the order followed by nature in the production of these beings? To resolve this question, we must also endeavour to deduce some principle from nature herself, with a view to such conformity; for if we were to determine the general distribution of animals according to the progression which exists in the animal organization, it appears that we might, in that progression, proceed with as much reason from the most composite to the most simple, as from the most simple to the most composite. Such a proceeding, however, could not rest on a proper basis; for we shall find that nature, consulted in the order of her operations in regard to animals, indicates the following principle, which excludes all arbitrary selection:—*Nature always operating in a gradual manner, and consequently never producing animals otherwise than successively, has obviously proceeded in such a production from the most simple towards the most complex.* We ought, therefore, in our general distribution, to imitate the order which nature herself has followed. "J'ai, en effet, montré," says Lamarck, "dans ma *Philosophie Zoologique* (tome i. p. 269), que, pour rendre la distribution générale des animaux conforme à l'ordre qu'a suivi la nature en produisant toutes les races qui existent, il fallait procéder du plus simple vers le plus composé,—c'est-à-dire, qu'il était nécessaire de commencer cette distribution par les plus imparfaits des animaux, et les plus simples en organisation, afin de la terminer par les plus parfaits, par ceux qui ont l'organisation la plus composée." He further observes, in his *Anim. sans Vert.* "Cet ordre est le seul qui soit naturel, instructif pour nous, favorable à nos études de la nature; et qui puisse, en outre, nous faire connoître la marche de cette dernière, ses moyens, et les lois qui régissent ses opérations à leur égard." Although we may find it less pleasant or conformable to our habitual taste to present at the head of the animal kingdom creatures of the most limited perceptions, excessively minute in size, and of scarcely any consistence in their parts,—yet as in all things it is necessary to consider the end in view, and the means which conduct towards it, Lamarck is of opinion that the arrangement established by usage in the distribution of animals is precisely that which leads us away from the point in view, as well as the least favourable for our instruction, and that it opposes the greatest number of obstacles in the way of our perceiving the plan, the order, and the means employed by nature in her operations concerning the animal world.

If in the study and examination of living bodies we had no other object in view than to distinguish the one from the other by characters deduced from their external forms—and if we were not desirous to regard their various and wonderful faculties otherwise than as simple matters of amusement, not altogether unfitted to excite the curiosity of a leisure hour—then the most ordinary and artificial system would suffice; for in that case it would be useless to occupy ourselves with researches concerning the affinities of animals, or to study their internal structure. But all naturalists are now agreed regarding the high importance of these affinities, and the necessity of holding them ever in view in our general arrangement of the animal kingdom. The bat is no longer classed with birds merely because, like them, it wings its way through the air; nor are seals or whales regarded as fishes because the dense nature of the medium which they inhabit requires a somewhat analogous form; neither are cuttlefish and polypi confounded together, though the mouth of each is surrounded by numerous arms.

We have dwelt at greater length than we intended on the system of Lamarck, or rather on the views by which he seeks to illustrate the principles on which his system professes to be built. Though occasionally prolix, and sometimes rather obscure, his observations, on the whole, are well deserving of an attentive consideration. Like most of his countrymen, he is unfortunately more regardful of secondary causes, and more anxious to illustrate their fitness and sufficiency, than he is ready to acknowledge the source from which they spring, or to admire the wisdom and beneficence of their providential institution.[1]

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[1] "The doctrine of Epicurus, that the Deity concerns not himself with the affairs of the world or its inhabitants, which, as Cicero has judiciously observed (*De Nat. Deor.* lib. i. ad calcem), while it acknowledges a God in *words*, denies him in *reality*, has furnished the original stock upon which most of these bitter fruits of modern infidelity are grafted. Nature, in the eyes of a large proportion of the enemies of revelation, occupies the place, and does the work, of its great Author. Thus Hume, when he writes against miracles, appears to think that the Deity has delegated some or all of his powers to nature, and will not interfere with that trust (*Essays*, ii. 75); and, to name no more, Lamarck, treading in some measure in the steps of Robinet (who supposes that all the links of the animal kingdom, in which nature gradually ascends from low to high, were experiments in her progress towards her great and ultimate aim, the formation of man—Barclay *on Organization*, &c. 263), thus states his opinion:—"La nature, dans toutes ses opérations, ne pouvant procéder que graduellement, n'a pu produire tous les animaux à la fois; elle d'abord n'a formé que les plus simples; et passant de ceux-ci jusques aux plus composés, elle a établi successivement en eux différens systêmes d'organes particuliers, les a

We shall now proceed to the system of another naturalist, also highly accomplished in the science, M. Dumeril, the friend and pupil of Baron Cuvier, and to whose collection of the oral demonstrations of his great master we were originally indebted for the publication of the *Leçons d'Anatomie Comparée.*

Table of the Classification of Animals, according to the System of Dumeril.

Internally articulated; vertebrated;	with mammæ; viviparous			1. MAMMIFERÆ.
	without mammæ; oviparous;	lungs;	feathers, wings	2. BIRDS.
			neither feathers nor wings	3. REPTILES
		no lungs;	branchiæ	4. FISHES.
Externally articulated; invertebrated;	articulated members;	tracheæ		5. INSECTS.
		branchiæ		6. CRUSTACEA.
	no articulated members			7. WORMS.
Not articulated;	distinct respiratory organs; vessels			8. MOLLUSCA.
	no respiratory organs; no vessels			9. ZOOPHYTES.

The ensuing tabular view exhibits the classification proposed by M. de Blainville. We shall leave the reader to judge for himself of the propriety of introducing so many new appellations for groups constructed long ago. His nomenclature is no doubt intimately connected with his views of the structure and physiology of animals, and is highly approved of and adopted by many competent judges of the science.

SYNOPTICAL TABLE of the PRIMARY, SECONDARY, TERTIARY, and QUATERNARY DIVISIONS of the ANIMAL KINGDOM, denominated *Sub-Kingdoms, Types, Sub-Types,* and *Classes,* by M. de Blainville. From the *Principes d'Anatomie Comparée* of that author.

ANIMAL KINGDOM.

						Classes.
I. Sub-Kingdom. Regular or ARTIOMORPHOUS Animals. ARTIOZOAIRES.	articulated	*Type I.* interiorly. OSTEOZOAIRES.	*I. Sub-Type.* Provided with mammæ and ...hairs; VIVIPAROUS.			1. PILIFERES or MAMMALIA.
			II. Sub-Type. Without mammæ. OVIPAROUS.	Provided with	feathers	2. PENNIFERES or BIRDS.
					scales	3. SQUAMMIFERES or REPTILES.
					naked skin	4. NUDIPELLIFERES—AMPHIBIA.
					fins	5. PINNIFERES or FISHES.
		Type II. exteriorly. ENTOMOZOAIRES, or articulated animals. With appendages,		articulated to the number of	3 pair	6. HEXAPODES.
					4 pair	7. OCTOPODES.
					5 pair	8. DECAPODES.
					variable	9. HETEROPODES.
					7 pair	10. TETRADECAPODES.
					= the segments	11. MYRIAPODES.
				not articulated		12. CHITOPODES.
				none		13. APODES.
	sub-articulated	*Type III.* MALENTOZOAIRES or MOLLUSCARTICULES				14. NEMATOPODES. 15. POLYPLAXIPHORES.
	not articulated	*Type IV.* Malacozoaires Molluscous animals.		The head	distinct	16. CEPHALOPHORES.
					not distinct	17. ACEPHALOPHORES.
II. Sub-Kingdom. Radiated or ACTINOMORPHOUS Animals.		ACTINOZOAIRES.	sub-radiated			18. ANNELIDAIRES.
			normal or true			19. CERATODERMAIRES. 20. ARACHNODERMAIRES. 21. ZOANTHAIRES. 22. POLYPIAIRES. 23. ZOOPHYTAIRES.
III. Sub-Kingdom. Irregular or HETEROMORPHOUS Animals.		HETEROZOAIRES				24. SPONGIAIRES. 25. MONADAIRES or MOLECULAIRES. 26. DENDROLITHAIRES.

multipliés, en a augmenté de plus en plus l'énergie, et les cumulant dans les plus parfaits, elle a fait exister tous les animaux connus avec l'organisation et les facultés que nous leur observons." (*Anim. sans Vertèbr.* i. 123.) Thus denying to the Creator the glory of forming those works of creation, the animal and vegetable kingdom (for he assigns to both the same origin, *ibid.* 83), in which his glorious attributes are most conspicuously manifested; and ascribing them to nature, or *a certain order of things*, as he defines it (214)—a blind power, that operates necessarily (311), which he admits, however, to be the product of the will of the Supreme Being (216). It is remarkable, that in his earlier works, in which he broaches a similar opinion, we find no mention of a Supreme Being. (See his *Système des Animaux sans Vertèbres; Discours d'Ouverture.*) Thus we may say, that, like his forerunner Epicurus, *Re tollit*, dum *oratione relinquit Deum.* But though he ascribes all to *nature*, yet, as the *immediate* cause of all the animal forms, he refers to the local circumstances, wants, and habits of individual animals themselves: these he regards as the modifiers of their organization and structure (162).

Animal Kingdom.

Let us here note, that M. Desmoulins, in the 2d edition of Dr Magendie's *Physiology* (1825), has exhibited a system in which the principles of Cuvier and De Blainville are joined in one.

A learned and ingenious Scotsman, Mr William Sharpe Macleay, is the author of several profound and original views in natural history. The unbroken and continuous succession, or linear series, in which systematic writers had previously regarded the objects of their contemplation, was first deviated from by Lamarck, who, in his supplement to the first volume of his *Animaux sans Vertèbres*, presented the *Invertebrata* in a double subramose series, consisting of articulated and inarticulated animals. The following are the principal bases of Mr Macleay's system.[1]

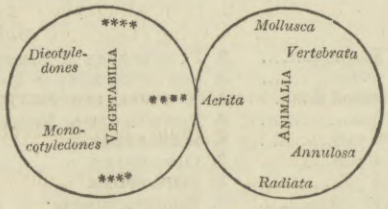
1. That all natural groups, whether kingdoms or any subdivision of them, return into themselves; a distribution which Mr Macleay expresses by circles.

2. That each of these circles is formed precisely of *five* groups, each of which is resolvable into five other smaller groups, and so on till we reach the extreme term of such division.

3. That proximate circles or larger groups are connected by the intervention of lesser groups, denominated *osculant*.

4. That there are relations of analogy between the corresponding points of contiguous circles.

The author has represented his system by tables of circles, inscribed with the names of the five primary divisions of each group. The following table exhibits his general view of the animal and vegetable kingdoms:



It will be perceived by the preceding diagram, that Mr Macleay divides the animal kingdom into five great sub-kingdoms, viz.

1. ACRITA, composed of the *infusoria*, the *polypi*, the *corallines*, the *tæniæ*, and the least organized of the *intestinal worms*.

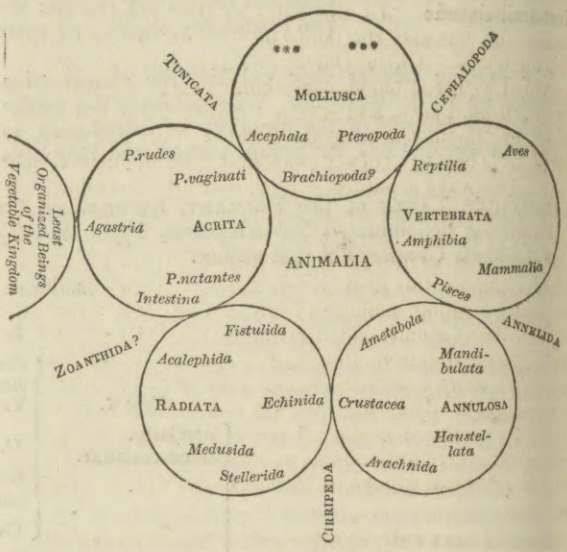
2. RADIATA, containing *medusæ*, *star-fish*, *sea-urchins* or *echini*, and others.

3. ANNULOSA, consisting of *insecta*, *arachnida*, and *crustacea*.

4. VERTEBRATA, constituted by *beasts*, *birds*, *reptiles*, *amphibia*, and *fishes*.

5. MOLLUSCA, including the numerous tribes of *shell-fish* or *marine testacea*, *fresh-water shells*, *snails*, *slugs*, &c. which, from the analogies presented by their soft or mucous substance, the peculiarities of their nervous system, and the general imperfection of their senses, appear as it were to return again to the *acrita*, though allied to the *vertebrata* by characters drawn from the possession of a heart and a circulating system.

The ensuing set of circles exhibits the further subdivision of the five sub-kingdoms into classes.



The *osculant* classes are such as are placed between the circles. In the molluscous circle two classes are still wanting to complete the quinary arrangement of that great division. According to Mr Kirby, the number *five*, assumed by Mr Macleay as a principal basis of his system, and as consecrated in *nature*, ought to yield to the number *seven*, which is consecrated both in *nature* and *scripture*. Metaphysicians enumerate *seven* principal operations of the mind, musicians *seven* principal tones, and opticians *seven* primary colours. In scripture, the abstract idea of this number is, *completion*, *fullness*, *perfection*. Mr Kirby seems to think that Mr Macleay's *quinaries* may be found resolvable into *septenaries*, in consequence of future investigations.[2]

We shall enter at greater length into a detailed expo-

To show the absurd nonplus to which this his favourite theory has reduced him, it will only be necessary to mention the individual instances which, in different works, he adduces to exemplify it. In his *Système* he supposes that the webfooted birds (*Anseres*) acquired their natatory feet by frequently separating their toes as far as possible from each other in their efforts to swim. Thus the skin that unites these toes at their base contracted a habit of stretching itself; and thus in time the web-foot of the duck and the goose was produced. The waders (*Grallæ*), which, in order to procure their food, must *stand* in the water, but do not love to *swim*, from their constant efforts to keep their bodies from submersion, were in the habit of always stretching their legs with this view, till they grew long enough to spare them the trouble!!! (13). How the poor birds escaped drowning before they had got their web-feet and long legs the author does not inform us. In another work, which I have not now by me, I recollect he attributes the long neck of the camelopard to its efforts to reach the boughs of the mimosa, which, after the lapse of a few thousand years, it at length accomplished!!! In his last work he selects as an example one of the *Moluscæ*, which, as it moved along, felt an inclination to explore by means of touch the bodies in its path: for this purpose it caused the nervous and other fluids to move in masses successively to certain points of its head, and thus in process of time it acquired its horns or tentacula!! (*Anim. sans Vertèbr.* i. 188.) It is grievous that this eminent zoologist, who in other respects stands at the head of his science, should patronize notions so confessedly absurd and childish." (*Introduction to Entomology*, by Kirby and Spence, vol. iii. p. 349.)

[1] See *Horæ Entomologicæ*, and Kirby & Spence's *Introduction to Entomology*, vol. iii. p. 12.

[2] *Introduction to Entomology*, vol. iii. p. 15. The quinary system, in its application to insects and other annulose animals, is pretty fully developed by its ingenious author in his *Horæ Entomologicæ*, already more than once referred to. An excellent paper by Mr Vigors, on the classification of birds, in accordance with the same system, will be found in the 14th volume of the *Transactions of the Linnæan Society*.

sition of the quinary system of arrangement under the articles *Entomology* and *Ornithology*.

Cuvier divides the animal kingdom into four principal branches. Setting aside all accessory and artificial characters, he proceeds upon the consideration of the essential structure of animals, and thus deduces four great groups or separate types of form, to one or other of which all the minor divisions may be ultimately referred.

In the first of these forms the brain, and the great central trunk of the nervous system called the spinal marrow, are protected by strong bony coverings—the cranium and vertebral column. To the sides of that column are attached the ribs and the bones of the anterior and posterior members. All the classes of this primary division are provided with red blood, a muscular heart, a mouth with two horizontal jaws, and special organs of vision, hearing, taste, and smell, placed in the head or upper and anterior portion. They have never more than four members; their sexes are always separate; and they nearly resemble each other in the distribution of their medullary masses, and the principal branches of their nervous system. On examining more narrowly the constituent parts of the classes which compose this great assemblage, it is easy to discover many striking analogies both of form and structure, even in those groups which are most distantly related to each other; and from the human species to the last of the fishes there exists an obvious conformity to the same general plan. The name of VERTEBRATED ANIMALS is bestowed on this division, on account of their being possessed of a vertebral column or back-bone. The following are the principal groups or classes into which it is further divisible.

FIRST PRIMARY DIVISION: ANIMALIA VERTEBRATA.

Class 1st. Man, mammiferous land-animals, and cetacea.
Class 2d. Birds.
Class 3d. Reptiles.
Class 4th. Fishes.

The second great division possesses no skeleton. The muscles are attached to the skin, which forms a soft contractile envelope; and many of the species are protected by hard coverings, commonly called shells, which are supposed to occupy in the cutaneous system of this form of animal life the same station as the mucous membrane of the preceding division. The nervous system is contained along with the viscera within this general envelope, and is composed of many dispersed portions, of which the principal, placed above the œsophagus, may be regarded as representing the brain. Of the four special senses it is impossible to discover the organs of more than two, taste and sight; and even of these the last is frequently wanting. The organs of hearing are visible only in one family. The system of circulation is however complete; there are particular organs for the performance of respiration; and the functions of digestion and secretion are almost as complicated as in the vertebrated classes. The subdivisions of this second form are called MOLLUSCOUS ANIMALS; and although the external configuration of their parts does not exhibit the same agreement as that of the vertebrated classes, there is always a corresponding resemblance in their essential structure and functions. The following are the classes of this branch of the animal kingdom.

SECOND PRIMARY DIVISION: ANIMALIA MOLLUSCA.

Class 1st. Cephalopoda, *e. g.* cuttle-fish, nautili, belemnites, argonauts, &c.
Class 2d. Pteropoda. Genus Clio, &c.
Class 3d. Gasteropoda. Slugs, snails, and numerous groups of turbinated shells.
Class 4th. Acephala. Oysters, mussels, and other bivalve shells, &c.
Class 5th. Brachiopoda. Terebratulæ, &c.
Class 6th. Cirrhopodes. Barnacle shells, &c. Lepas and Triton. (Linnæus.)

The third great preponderating form is represented by insects and other analogous classes. Their nervous system consists of two long ventral or sublateral chords, which swell out at intervals into knots or ganglia. The first of these ganglia, placed *above* the œsophagus, is analogous to the brain, although it does not exceed in size and scarcely in importance the ganglia of the lengthened cords, with which it communicates by means of a ring which embraces the œsophagus like a collar. The general covering of the body in this division is sometimes hard, sometimes soft, and is divided into segments by a certain number of transverse incisions. The muscles are always attached to the interior, and the body is usually, though not universally, provided with articulated members. It is among the classes of this form that we begin to perceive the passage from a system of circulation in closed vessels called arteries and veins, to nutrition derived from imbibition; and a corresponding passage from respiration in circumscribed organs to that performed by tracheæ or air-vessels, distributed over the whole body, is likewise observable. The organs of taste and sight are the most distinct in this branch; the organ of hearing is apparent only in a single family, although we can scarcely doubt that the sense exists in others in which the organ has not been ascertained. The following classes are ranked under this great form.

THIRD PRIMARY DIVISION: ANIMALIA ARTICULATA.

Class 1st. Annelides. Serpulæ, nereids, leeches, earth-worms, the hair-eel, &c.
Class 2d. Crustacea. Crabs, lobsters, shrimps, &c.
Class 3d. Arachnides. Spiders, scorpions, mites, &c.
Class 4th. Insecta. Beetles, flies, butterflies, &c.

In the three preceding divisions, the organs of movement and of sensation are disposed symmetrically on both sides of an axis, with an anterior and posterior portion differing from each other. Among the zoophytes, which form the last great division, the organs are usually disposed in a radiated form. They approach the nature of plants in the extreme simplicity of their structure. They have no distinct nervous system, nor organs of the special senses; and it is barely possible to detect in a few of the species some slight vestige of the circulating system. Their respiratory organs are almost always on the surface of their bodies. The greater proportion of the classes exhibit no other intestine than a sack or cæcum, and the composition of the last groups of all presents only a homogeneous pulpy mass, sensible, and endowed with motion. From a consideration of their most usual forms, the classes of this order are named RADIATED ANIMALS. They are as follows:—

FOURTH PRIMARY DIVISION: ANIMALIA RADIATA.

Class 1st. Echinodermata. Star-fish, sea-urchins, &c.
Class 2d. Entozoa. Intestinal worms.
Class 3d. Acalephæ. Sea-nettles, actiniæ, medusæ, &c.
Class 4th. Polypi. Corals, madrepores, sponges, &c.
Class 5th. Infusoria. Infusory and other microscopical animals.

Such are the great outlines of a system which, considered in its generality, is certainly the most satisfactory which has yet appeared. Particular departments may have been filled up, modified, and perhaps improved by ingenious observers, sedulous within a limited sphere (and of these ameliorations we shall be careful to avail ourselves when we come to enter upon a detailed view of each of the classes of the animal kingdom); but the construction and position of the principal groups, their real as well as relative characters, are developed in the system of the great French anatomist, in a manner more clear and accordant with nature than in any other yet promulgated. We shall therefore in the course of this work adhere, with some slight transpositions, the reasons for which will be stated in their proper place, to the classes of Baron Cuvier. The greater extent and importance of some of these, in comparison with others, will induce us to bestow more attention and a larger space to their illustration; and as certain of the primary divisions, such as the Mollusca and Radiata, contain a greater number of classes, if not of less importance, at least by no means so strongly characterized or contradistinguished from each other as are those of the vertebrated tribes, we shall, in presenting the history and nomenclature of such classes, group them together in such a manner as to exhibit them to the reader either under one of the great primary divisions, or as an intermediate subdivision, containing one or more classes. For example, the article MOLLUSCA of this work will present consecutively under a single head the history and classification of the six classes contained in the second primary division so named;—but the four classes of vertebrated animals will be each discussed in a separate treatise. Thus mammiferous animals, birds, reptiles, and fishes, will form the articles MAMMALIA, ORNITHOLOGY, REPTILIA, and ICHTHYOLOGY. The Classes of the third primary division, viz. Annelides, Crustacea, Arachnides, and Insecta, will (with the exception of the first, referred to Helminthology) likewise be treated of under distinct heads, in the alphabetical order, of the following terms:—CRUSTACEA, ARACHNIDES, and ENTOMOLOGY. In regard to the fourth primary division, that of the radiated animals, commonly called Zoophytes, the first class, named ECHINODERMATA, will be treated of separately under its own title; the second class, *Entozoa*, which contains the intestinal worms, will be grouped with the Annelides or red-blooded worms (as above excepted from the third primary division); and these two classes will be treated of together under the article HELMINTHOLOGY. The remaining classes of the Animalia Radiata, that is to say, the Acalephæ, the Polypi, and part of the Infusoria, as they form the last links of the animal kingdom, will come to be discussed with greater propriety at the concluding stage of this work, under the head of ZOOPHYTES. Finally, that portion of the infusorial class which we have excepted in the above distribution will be found described in the present volume under the word ANIMALCULE. This completes the exposition of our zoological system.

The following enumeration exhibits a view of the terms under which the principal subjects of zoology will be explained and illustrated in the course of this work.

Systematic Arrangement.	*Alphabetical Arrangement.*
Mammalia.	Animalcules.
Ornithology.	Arachnides.
Reptilia.	Crustacea.
Ichthyology.	Echinodermata.
Mollusca.	Entomology.
Crustacea.	Helminthology.
Arachnides.	Ichthyology.
Entomology.	Mammalia.
Echinodermata.	Mollusca.
Helminthology.	Ornithology.
Zoophytes.	Reptilia.
Animalcules.	Zoophytes. (T.)

ANIMAL Magnetism. See MAGNETISM, *Animal.*

ANIMALCULE.

ANIMALCULE, a diminutive term (from the word animal), applied by naturalists to those minute beings which become apparent in various fluids when subjected to the microscope. They were named infusory animals (*Infusoria*) by Müller, one of the most celebrated observers in this department of zoology; and the appellation, however inapplicable, now occurs in the majority of scientific publications. Of course it applies with propriety only to such species as are developed through the medium of infused substances. Now we know, that of 400 species of Infusoria (commonly so called) described by Müller himself, not a sixth part were observed in any kind of infusions; whilst the remainder inhabited the most translucent waters, and speedily died when placed in impure or corrupted liquids. Even the word animalcule (or little animal) does not convey a positive or sufficiently restricted idea in relation to this particular class; because mites and certain polypi are extremely minute in their dimensions, and equally require the aid of microscopical investigation; and thus the term microscopics (*microscopiques*), recently proposed by M. Bory de St Vincent, is not less faulty than its predecessors. The size of an animal, in fact, bears no essential relation to the other conditions of its organization; and therefore we cannot infer its nature with any certainty from a knowledge of its dimensions. At the same time it must be admitted, that the most simply organized, both of plants and animals, are also the most minute; and thus the Infusoria may be regarded as possessed of certain characters in common. We here adopt the word Animalcule, chiefly because it is the most familiar to the English reader.

The subjects of our present observations may be thus defined:—*Animals invisible to the naked eye;*[1] *more or less translucent; unprovided with members* (the caudal, and other appendices, with which certain species are furnished, being scarcely regardable as such); *no perceptible eyes; contractile in whole or in part; endowed with the sense of touch; deriving nourishment by absorption; generation* (when not apparently spontaneous, and consequently incomprehensible) *effected by division, or by the emission of gemmules or oviform bodies; inhabitants of liquids.* They are the smallest and most simple of living creatures, but not less perfect than the other tribes; for though they possess the fewest faculties, their means are in every way adequate to their wants, and their vital energies proportioned to their sphere of enjoyment.

Among microscopical animals we find many species which, in their aspect and structure, present no analogy

[1] The *Volvox globator*, and a few others, which are just discernible without the aid of a microscope, form exceptions to the above character.

o other forms of animal life: they are merely moving nolecules of the simplest organization, the exact nature of which it is sometimes difficult to determine, and which involve in deeper obscurity the mysterious line of demarcation by which we so often seek in vain to separate the animal from the vegetable kingdom. If, however, the rue distinction between plants and animals consists chiefly n the irritability and power of contraction possessed by he latter, then the Infusoria, which are strongly endowed with these attributes, are indeed so far removed from the egetable kingdom, that the name of Zoophytes, or animal lants, is inapplicable to the class to which they belong. n the extreme simplicity of their structure, they no doubt resent some analogy to the least complicated tribes of lants, such as the algæ and others; but it is a mere anagy, and not a connection of affinity,—for no alliance beween these kingdoms has ever been demonstrated, alhough certain obscure phenomena may have presented ifficulties in the way of our investigations. "We need ot be surprised," Mr Macleay observes in his *Horæ Enmologicæ*, "that several of the Linnæan algæ should be till hovering in a state of uncertainty between the two ingdoms; but, on the contrary, be prepared to expect aditional proofs of the analogy which the two great divisions f organized matter bear to each other. The Agastria, or agastraires of De Blainville, are indeed *animals*, though hey have neither distinct organs of sense, alimentary cal, nor even mouth,—though they have, in short, so far s our present knowledge of them would lead us to beeve, no internal digestion whatever to execute, but trust or nourishment, like plants, to the absorption of their exernal pores. They must be esteemed animals on account f their peculiar irritability; but are vegetables in almost very other respect."

Our knowledge of the history of animalcules resulted rom the improvement of the microscope by Hartzoeker nd Leeuwenhoeck. The ancients were consequently unequainted with the mysteries of this "invisible world;" nd we are thus saved the tedium of a lengthened bibliraphical investigation. Notwithstanding the observations f Hill, Baker, Ledermuller, Goeze, Gleicken, Roësel, Pallas, Needham, Spallanzani, and several other minute nd laborious inquirers, it may be said that this branch of oology only assumed a truly scientific form in conseuence of the labours of a distinguished Danish naturalist, Otho Frederic Müller. His earlier works, such as the *Vermium Terrestrium et Fluviatilium Historia*, and the *Zoologiæ Danicæ Prodromus*, presented very decided improvenents in the knowledge and classification of animalcules. These emendations were transferred by Gmelin to the 3th edition of the *Systema Naturæ* of Linnæus, in which nimalcules form the fifth order of the class of Vermes. But the work which, had the rest been wanting, would lone have immortalized the name of Müller, appeared posthumously) in 1786, under the title of *Animalcula Infusoria, Fluviatilia et Marina*. It is illustrated by 50 plates, ontaining figures of 360 species variously represented. A later and very useful compendium of knowledge regardng microscopical animals forms a portion of the *Encyclopédie Méthodique* (46th livraison), in which Bruguière has eproduced the plates of Müller, with the addition of seveal others of equal accuracy from the third volume of Roësel's *Insecten-belustigungen*. The reader will there find lescriptions of 28 plates, containing nearly 1100 figures epresenting 385 animalcular species.

Before proceeding further, we shall present a brief view of the system of Müller, as of high importance in itself, and the fundamental basis of the more recent and improved arrangements. It includes, however, several genera which are not now classed among the animalcular tribes. He divides the Class of Animalcula Infusoria as follows:

Order I.—*No External Organs.*

* *Thickened.*

Genus 1. *Monas;* body punctiform. 10 species.
2. *Proteus;* body variable. 2 species.
3. *Volvox;* body spherical. 12 species.
4. *Enchelis;* body cylindrical. 27 species.
5. *Vibrio;* body elongated. 31 species.

* * *Membranous.*

6. *Cyclidium;* body oval. 10 speeics.
7. *Paramœcium;* body oblong. 5 species.
8. *Kolpoda;* body sinuous. 16 species.
9. *Gonium;* body angular. 5 species.
10. *Bursaria;* body excavated. 5 species.

Order II.—*External Organs.*

* *Naked.*

11. *Cercaria;* smooth, tailed. 22 species.
12. *Trichoda;* haired or ciliated. 89 species.
13. *Kerona;* with horny appendices. 14 species.
14. *Himantopus;* with cirrated appendices. 7 species.
15. *Leucophra;* the entire surface ciliated. 26 species.
16. *Vorticella;* orifice ciliated. 75 species.

* * *Furnished with a Shell.*

17. *Brachionus;* orifice ciliated. 22 species.

In the year 1815 Lamarck published the first part of his *Animaux sans Vertèbres*, a work which forms an epoch in the history of the inferior tribes. In this signal publication the author adopts a different course from that usually followed by systematic writers; and pursuing an ascending rather than a descending scale, he commences with the lowest and least complex species, viz. the Infusoria. From this class, however, he rejects all those species in which any kind of complication of organs is apparent. All the genera so distinguished are referred by him to the first order of the second class of the animal kingdom, called Polypi, under the title of *Polypi ciliati;* and the true and restricted Infusoria are thus defined: *Microscopical animals, gelatinous, transparent, polymorphous, contractile; having no distinct mouth, nor constant, determinable, internal organs; generation fissiparous or sub-gemmiparous.* The genus Kerona, it may be further remarked, is in this system united to the Himantopus of Müller, while the genus Cercaria of that author is divided into two. Thus the class Infusoria of Lamarck, composed of two great sections, the naked and the appendiculated, may be said to correspond to the first 14 genera of the Danish naturalists.

Cuvier, in the *Règne Animal* (1817), places the Infusoria as a part of his fourth great division, the zoophytical or radiated animals. The term *radiated* was originally bestowed on a numerous tribe of animals, such as the Asterias and others, on account of their arms or tentacula being extended in a radiated or star-like form; but it certainly applies unfitly to the true Infusoria of Lamarck, which possess nothing resembling a radiated structure. It cannot, however, be always expected that a general term of wide import should apply with etymological accuracy to every part of the extensive series which it is intended to embrace. Cuvier then divides his Infusoria into two orders, *Les Rotifères*, and *Les Infusoires homogènes*, the former of which correspond to the ciliated polypi of La-

Animalcule.

marck, the latter to the Infusoria properly so called of that author.

According to M. de Blainville, the class Infusoria can scarcely be regarded as established upon a natural foundation. The organization of its component tribes is so various as to lead to the belief that a more precise knowledge would show that several of those tribes belong to different types of the animal kingdom. Some, as the genus Brachionus, are symmetrically formed both as regards their bodies and appendages, and are protected by a horny or crustaceous covering. Others, as Vibrio, Paramæcium, &c. have the body elongated, depressed, vermiform, and without appendages. A third division exhibit a radiated structure, as for example the Vorticellæ, which, however, we have already stated, are now seldom classed among the Infusoria. Many genera, such as Proteus, Volvox, Monas, are amorphous, or without determinate form, and cannot be referred to any other known type of the animal kingdom. They are regarded by many as the elementary molecules of all animal life, and in their structure no other than the cellular tissue is observable. They may be said to be dependent on external circumstances, instead of being able, like other animals, to modify or control them; and their usually spherical form is the necessary result of an equal pressure of water on all sides of a frail and yielding texture. M. de Blainville considers the genera *Brachionus*, *Urcelaria*, *Cercaria*, *Furcularia*, *Kerona*, *Trichocerca*, and *Himantopus*, as belonging to the type of *Entomozoaires* or articulated animals, and especially to the class Heteropoda, order Entomostraca. Many species of *Vibrio* he regards as Apodes, as well as *Paramæcium* and *Kolpoda*. Other species of the genera *Vibrio* and *Cyclidium* ought rather to be ranged with the Planaria; and in the genus *Leucophra* there is even a species which M. de Blainville is inclined to look upon as an Ascidia! Finally, the genera *Gonium*, *Proteus*, *Volvox*, and *Monas*, if they are really animals, appear to form a distinct type, which may be called Amorphes or Agastraires; so named from the circumstance of their having neither determinate form nor reduplication of the external envelope for the formation of a stomach, as in all other true animals.

Such is a brief exposition of the views of one of the most distinguished physiological inquirers of the present day. It may serve, if for nothing more, at least to show the unsettled state of opinion concerning these extraordinary creatures. In regard to this, however, we may rest assured that, in the future progress of science, the class Infusoria, as at present constituted, will suffer an entire dismemberment, and its component parts will be referred to various groups of the animal kingdom, some of them widely distant from each other.

In the year 1826 a full and most elaborate classification of microscopical animals was given to the world by M. Bory de St Vincent. As it is the singular mode of existence of animalcular beings, their general economy in the field of nature, the actual conditions of their organization, and the state of their limited faculties so far as these can be ascertained, with which we are chiefly interested—so, in our systematic view of this extraordinary class, we shall merely present to our readers the characters of the principal genera, and of a few of the most remarkable species which they contain. But, as some may be desirous to possess at least a sketch of the full extent and condition of this intricate subject, we have constructed the accompanying tabular scheme of the orders, families, and genera of microscopical animals, according to the views of M. Bory de St Vincent, the latest and most assiduous writer on this department with whose labours we are acquainted. We have thought it advisable to retain the terms of the original language, lest, by inadvertence or misconception on the part of the translator, any additional obscurity should rise around a subject already sufficiently encumbered. (*See Tabular View on the opposite page.*)

The order Gymnodes of Bory de St Vincent nearly corresponds to the entire class Infusoria of Lamarck; and although the observations by which he illustrates his arrangement partake of the accustomed defects of the French philosophy, the facts which he details, if not the theoretical views which he inculcates, are worthy of an attentive consideration. These mysterious creatures are observed to swim with astonishing rapidity; and although their bodies are usually diaphanous, it has hitherto proved impossible, even by the aid of the most powerful glasses, to ascertain by what natural mechanism these movements are effected. They direct their courses by a discretionary power, in one direction rather than another, avoiding and turning round opposing obstacles, according to the necessities of the case—discerning, as the process of evaporation proceeds, the points in which they may prolong their existence, and flocking in crowds to those places where they are best screened from the overpowering brilliancy of the reflecting mirror. They thus appear to possess volition, which we are accustomed to regard as a result dependent on the faculties of perception and comparison.

The principal obstacle to our understanding the essential nature of animalcules results from their want of a nervous system, which, in ourselves, and in all the intermediate classes of the nature of whose consciousness we have even a vague idea, we regard as the *sine qua non* of sensation and intelligence. Voluntary motion without muscular action is also a circumstance which we cannot very clearly comprehend. But as there may be "more things in heaven and earth than are dream't of in our philosophy," we must not reject facts, that is to say appearances which present themselves under the same determinate and uniform aspect to various unprejudiced observers, merely because they do not coincide, or may possibly controvert or interfere, with a previous hypothesis. On the other hand, the extreme softness of texture, and excessive minuteness, of most of the animalcular species, render anatomical investigation almost impossible; and naturalists may have erred in supposing the absence of what they are merely unable to perceive and demonstrate.

It is in truth impossible to discover any traces of the nervous system, even among several tribes of animals in other respects much more highly organized than the subjects of our present inquiry. Trembley's examination of the Polypus threw no positive light upon the matter; nor did Gade's dissections of the larger Medusæ enable him to discover either muscular or nervous fibres. According to M. Bory de St Vincent, the nervous system is one of the last to be developed. To the perfect simplicity of the Monads, the first perceptible addition is that of a central cavity, or rudimentary intestinal sac, which we find to occur even before the existence of a mouth. Next appears an opening to this canal, which serves both for the reception of nourishment, and the rejection of excrementitious parts where such exist. The hairs and cirrated appendages which ensue in still more complicated species have been regarded as the early rudiments of the respiratory system; and even a heart, or central organ of a circulating fluid, is partly developed before the appearance of any nervous chords. The earliest, most general, and perhaps the only indispensable function of animal life, is that of nutrition. But the materials of nutrition are so different, and their modes of reception so various, that the exercise of this

Table of the Orders, Families, and Genera of Animalcules, according to a new Analytical Method. By Bory de Saint-Vincent.

MICROSCOPIQUES.	ORDRES.			FAMILLES.	GENRES.
Sans aucune apparence de test.	Parfaitement glabres, sans cils ni cirres vibratiles ... GYMNODÉS	Dépourvus d'appendices quelconques, soit caudiformes ou autres.	Jamais linéaires ni anguiformes. — De formes invariables. — Où chaque molécule est ou peut devenir un animal particulier. — Molécules toujours isolées, et formant autant d'individus	MONADAIRES	Corps anguleux, non arrondi: 1. *Lamellina.*
					Corps arrondi, jamais anguleux — Sphérique — Sans point central: 2. *Monas.*
					Corps arrondi, jamais anguleux — Sphérique — Marqué d'un point central: 3. *Ophthalmoplanis*
					Corps arrondi, jamais anguleux — Ovalaire comprimé: 4. *Cyclidium.*
			Molécules groupées, et comme formant un individu en commun	PANDORINÉES	Où les molécules groupées ne sont revetues d'aucune enveloppe commune — Se groupant en sphérules: 5. *Uvella.*
					Où les molécules groupées ne sont revetues d'aucune enveloppe commune — Se groupant en lames: 6. *Pectoralina.*
					Où les molécules groupées sont englobées dans une enveloppe commune: 7. *Pandorina.*
			Où les molécules demeurent irrévocablement asservies à une vie commune, et ne se désunissent jamais pour vivre isolément	VOLVOCIENS	Corps sphérique — Où la molécule interne laisse un anneau translucide autour du corps: 8. *Gyges.*
					Corps sphérique — Où la molécule interne remplit le corps sans laisser comme un anneau translucide circulaire: 9. *Volvox.*
					Corps pyriforme: 10. *Enchelis.*
			De forme plus ou moins variable. — Corps applani et ne s'excavant jamais	KOLPODINÉES	Corps jamais plissé à sa surface — Antérieurement denté: 11. *Triodonta.*
					Corps jamais plissé à sa surface — Non denté antérieurement — Simueux: 12. *Kolpoda.*
					Corps jamais plissé à sa surface — Non denté antérieurement — Amorphe: 13. *Amiba.*
					Corps muni d'un pli à sa surface: 14. *Paramæcium.*
			Corps excavé, ou susceptible de s'excaver	BURSARIÉES	Corps se creusant en bourse — Dépourvu de cloison interne: 15. *Bursaria.*
					Corps se creusant en bourse — Présentant un rudiment de cloison interne: 16. *Hirundinella.*
					Corps creusé en godet: 17. *Craterina.*
			Linéaires ou anguiformes	VIBRIONIDES	Corps opaque — Roulé en spirale discoide: 18. *Spirilina.*
					Corps opaque — Non roulé en spirale discoide: 19. *Melanella.*
					Corps diaphane — Atténué aux deux extrémités: 20. *Vibrio.*
					Corps diaphane — Obtusé — Atténué en cou, avec un bouton en manière de tête: 21. *Lacrimatoria.*
					Corps diaphane — Obtusé — Non atténué en cou, et sans bouton en manière de tête: 22. *Pupella.*
		Munis d'un ou de deux appendices caudiformes ou autres.	Normaux. — Un seul appendice caudiforme terminal	CERCARIÉES	Corps cylindracé — Polimorphes ou du moins contractiles — Où l'appendice est une continuation du corps graduellement aminci: 23. *Raphanella.*
					Corps cylindracé — Polimorphes ou du moins contractiles — Où l'appendice est comme implanté en queue: 24. *Histrionella.*
					Corps cylindracé — Non contractiles ni polymorphes — Sans carène sur aucun coté du corps: 25. *Cercaria.*
					Corps cylindracé — Non contractiles ni polymorphes — Corps présentant une carène sur un de ses côtés: 26. *Turbinella.*
					Corps comprimé — Point d'appendices latéraux — Appendice caudal non infléchi sur un côté du corps: 27. *Zoosperma.*
					Corps comprimé — Point d'appendices latéraux — Appendice caudal infléchi sur un côté du corps: 28. *Virgulina.*
					Corps comprimé — Deux petits appendices latéraux outre le caudiforme: 29. *Tripos.*
			Appendice double ou bifide	URODIÉES	Corps non vaginiforme, ni distinctement urcéolé — Non terminé en une sorte de tete — Les deux appendices distincts jusqu'à leur insertion — Continus avec le corps, et non infléchis: 30. *Furcocerca.*
					Corps non vaginiforme, ni distinctement urcéolé — Non terminé en une sorte de tete — Les deux appendices distincts jusqu'à leur insertion — Comme implantés au corps, et infléchis: 31. *Trichocerca.*
					Corps non vaginiforme, ni distinctement urcéolé — Non terminé en une sorte de tete — Les deux appendices se fourchant sur un pédicule et non sur le corps: 32. *Ty.*
					Corps non vaginiforme, ni distinctement urcéolé — Se terminant en une sorte de tete: 33. *Cephalodella.*
					Corps subvaginiforme ou urcéolé — Appendices terminaux: 34. *Leiodina.*
					Corps subvaginiforme ou urcéolé — Appendices latéraux: 35. *Kerobalana.*
			Genre anomal ; appendices en forme de herse épars sur l'une des surfaces de l'animal		36. *Tribulina.*
Où se distinguent des cils ou des cirres vibratiles.	Où des cils répandus sur toute la surface du corps, ou disposés diversement sur quelqu'une de ses parties, ne forment point d'organe vibratile particulier, et encore moins de rotatoires complets ... TRICHODÉS	Corps totalement dépourvu d'appendices caudiformes ou autres.	Où les cils couvrent ou environnent la totalité du corps	POLYTRIQUÉES	Velus — Corps ni fissé, ni appendiculé: 37. *Leucophra.*
					Velus — Corps fissé, ou appendiculé à l'une des extrémités: 38. *Diceratella.*
					Ciliés — Corps non antérieurement atténué en cou: 39. *Peritricha.*
					Ciliés — Corps antérieurement atténué en cou: 40. *Stravolæma.*
			Où les cils, ne couvrant pas ou n'environnant pas la totalité du corps, y sont répartis en faisceaux ou séries	MYSTACINÉES	Cils en un seul faisceau ou série — En un faisceau terminal — Corps antérieurement atténué en cou que termine un bouton en maniere de tete: 41. *Phialina.*
					Cils en un seul faisceau ou série — En un faisceau terminal — Corps non antérieurement atténué en cou, et que ne termine aucun bouton: 42. *Trichoda.*
					Cils en un seul faisceau ou série — En une série latérale — Corps sub-urcéolé: 43. *Ypsistoma.*
					Cils en un seul faisceau ou série — En une série latérale — Corps jamais sub-urcéolé: 44. *Plagiotricha.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Corps antérieurement fissé, ou les cils forment comme deux moustaches: 45. *Mystacodella.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Sans apparence d'ouverture buccale que bordent les cils — Cils de meme nature, dont les uns ne sont ni plus longs ni plus rigides que les autres — En deux groupes — Sérialement: 46. *Oxytricha.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Sans apparence d'ouverture buccale que bordent les cils — Cils de meme nature, dont les uns ne sont ni plus longs ni plus rigides que les autres — En deux groupes — Fasciculés: 47. *Ophrydia.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Sans apparence d'ouverture buccale que bordent les cils — Cils de meme nature, dont les uns ne sont ni plus longs ni plus rigides que les autres — En trois groupes: 48. *Trinella.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Sans apparence d'ouverture buccale que bordent les cils — Cils de diverse nature, dont les uns sont plus longs ou plus rigides que les autres: 49. *Kerona.*
					Cils en plus d'un faisceau ou série — Corps non antérieurement fissé — Avec une sorte d'ouverture buccale sur un coté que bordent les cils: 50. *Kondylostoma.*
			Corps terminé en appendices caudiformes	URODÉES	Appendice caudal simple: 51. *Ratulus.*
					Appendice caudal double: 52. *Diurella.*
	Où les cirres vibratiles, disposés sur les bords ou aux alentours d'un orifice buccal, deviennent vivement vibratiles — Où les cirres vibratiles ne forment pas de rotatoires complets distincts ... STOMOBLÉPHARÉS		Corps urcéolé	URCEOLARIÉES	Corps non contractile ni polymorphe: 53. *Myrtilina.*
					Corps contractile, plus ou moins polymorphe — Vaguant, et non stipité — Urcéole rempli par un corps qui se prolonge centralement en mammelon: 54. *Rinella.*
					Corps contractile, plus ou moins polymorphe — Vaguant, et non stipité — Urcéole entierement évidé — Postérieurement épais, obtus et non atténué: 55. *Urceolaria.*
					Corps contractile, plus ou moins polymorphe — Vaguant, et non stipité — Urcéole entierement évidé — Postérieurement atténué en pointe, et tubiforme: 56. *Stentorina.*
					Corps contractile, plus ou moins polymorphe — Stipité, et se fixant: 57. *Sinantherina.*
			Corps vaginé	THIKIDÉES	Corps fixé dans le fourreau — Appendice caudal simple — Deux filamens tentaculaires antérieurs: 58. *Filina.*
					Corps fixé dans le fourreau — Appendice caudal simple — Point de filets tentaculaires quelconques: 59. *Monocerca.*
					Corps fixé dans le fourreau — Appendice caudal composé — Bifide: 60. *Furcularia.*
					Corps fixé dans le fourreau — Appendice caudal composé — Trifide: 61. *Trichocerca.*
					Corps libre et non adhérant dans le fourreau: 62. *Vaginicola.*
	Où les cirres vibratiles forment des rotatoires complets et distincts ... ROTIFERES	(Cet Ordre ne contient qu'une famille)		ROTIFERES	Corps contenu dans une capsule en ampoule où il semble ne pas adhérer — Rotatoires non variables, constamment doubles — Sessiles: 63. *Foliculina.*
					Corps contenu dans une capsule en ampoule où il semble ne pas adhérer — Rotatoires non variables, constamment doubles — Pédicellés: 64. *Bakerina.*
					Corps contenu dans une capsule en ampoule où il semble ne pas adhérer — Rotatoire variable d'un à quatre lobes: 65. *Tubicolaria.*
					Corps non contenu dans une capsule en ampoule — Corps non vaginé, rotatoire bilobé: 66. *Megalotrocha.*
					Corps non contenu dans une capsule en ampoule — Corps vaginé, rotatoires complètement distincts: 67. *Ezechielina.*
	[illegible]	[illegible]	Munis de cirres vibratiles	BRACHIONIDES	Cirres vibratiles formant des rotatoires complets — Test capsulaire urcéolé — Corps terminé par une queue — Bifide: 68. *Brachionus.*
					Cirres vibratiles formant des rotatoires complets — Test capsulaire urcéolé — Corps terminé par une queue — Simple: 69. *Siliquella.*
					Cirres vibratiles formant des rotatoires complets — Test capsulaire urcéolé — Sans queue: 70. *Keratella.*
					Cirres vibratiles formant des rotatoires complets — Test univalve en carapace — Queue bifide terminale: 71. *Tricalama.*
					Cirres vibratiles formant des rotatoires complets — Test univalve en carapace — Queue non bifide, sub-centrale: 72. *Proboskidia.*
	[illegible]	[illegible]			Test non urcéolé — Univalve — Queue sub-centrale: 73. *Testudinella.*
	[illegible]	[illegible]			[illegible] 74. [illegible]
	[illegible]	[illegible]			faisceaux — Test urcéolé: 76. *Squatinella.*
	[illegible]	[illegible]	Dépourvus de cirres		Test capsulaire urcéolé: 77. *Silurella.*

Animalcule.

function by no means necessitates the existence of a mouth, a stomach, or an alimentary canal; for an increase of parts may be effected even through the medium of imponderable or elastic fluids, and by imperceptible and superficial pores.

The exterior of an infusory animal may be compared to the interior of one of the higher classes, in which nutrition is carried on by the reception of the chyle by the absorbent pores. These pores are external among the Infusoria, and the process of absorption is with them analogous to that of plants, in which there is a direct reception and appropriation of fluids from the earth and air, without any previous preparation in a central cavity or stomach. Zoophytes in general have indeed been called the cryptogamia of the animal kingdom. According to Carus, the Infusoria ought to be regarded merely as little cells, partially filled with lymph, and possessed of the powers of nutrition and locomotion; and thus the infinite changes and variations perceptible in their forms may be supposed to be produced by the various degrees in which this fluid is collected at one or other of the points of their bodies. In the opinion of that anatomist, a more complete development of the organs of motion, and indeed of the whole organization, is inseparably united with the appearance of a distinct nervous system. This may be true as a general rule, but not as a universal principle; for the Medusa has more apparent voluntary motion than the Asterias, though the former is destitute of those nerves which in the latter make their first appearance in the shape of a pale thread-like ring surrounding the œsophagus. It is this ring around the upper extremity of the alimentary canal which, in the molluscous and articulated classes, we shall afterwards find to constitute the most uniform and most essential portion of the nervous system. The Medusæ, just referred to, being almost of the same specific gravity with water, are easily carried by currents, and moved about from place to place by the action of the waves, or even (as in the case of *Holothuria physalis*) by the winds; but Carus and other writers have assuredly erred in doubting that they execute a voluntary locomotion; for that they do so in a very decided and graceful manner must be obvious to all who have attended to these animals in their native haunts along the shores, or among the land-locked waters of the beautiful firths of Scotland.

The mysteries revealed by the glasses of Leeuwenhoeck were at first regarded as beyond belief. The uncertainty of microscopical investigations, in consequence of which so much was supposed to depend on the imagination of the beholder, was alleged against them; and even at an after-period, when men of sober judgment and the most industrious application had confirmed the experience of the indefatigable Dutchman, the wit of Voltaire did not disdain to throw its cutting sarcasm over the disciples of the "anguilles de la pâte et du vinaigre." We hope it is now admitted, that however frequently those who endeavour to expound the mysteries of nature may fail in their attempts at elucidation, yet that there is nothing in the manifold works of Omnipotent Wisdom which, if duly studied and rightly understood, would not conduce to our wellbeing and happiness; and that a single square inch of water, with its many millions of animalcular atoms, is in truth as wonderful a work of divine intelligence, and as interesting a field for human investigation, as the starry galaxy of heaven.

In his tam parvis, atque tam nullis, quæ ratio!
Quanta vis! quam inextricabilis perfectio!

And if a heathen philosopher (Pliny) has so expressed his almost reverential admiration, is it not to be deplored that those whose labours might be carried on under the influence of a purer light, seem as often degraded as exalted by the contemplation of their Creator's works; and, referring all to the powers of nature, or some other indefinite abstraction, refuse to recognise, amid so many wonders, the "Good Supreme" from whom these and other mightier wonders have proceeded? It is in the study of the subject with which we are now engaged, and the analogous pursuits of physiology, where the completion of the most perfect design and the happiest results of superhuman forethought are so constantly manifested, that we frequently meet, where we should least expect it, with the sneer of the sceptic, or the impious ridicule of the unbeliever. How different are the sentiments of one who combines the piety of the Christian with the genius of the poet and philosopher. "But about the time of its invention (the invention of the telescope), another instrument was formed, which laid open a scene no less wonderful, and rewarded the inquisitive spirit of man with a discovery which serves to neutralize the whole of this argument. This was the microscope. The one led me to see a system in every star; the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and of its countries, is but a grain of sand on the high field of immensity; the other teaches me that every grain of sand may harbour within it the tribes and the families of a busy population. The one told me of the insignificance of the world I tread upon; the other redeems it from all its insignificance; for it tells me, that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless as are the glories of the firmament. The one has suggested to me, that beyond and above all that is visible to man, there may lie fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the universe; the other suggests to me, that within and beneath all that minuteness which the aided eye of man has been able to explore, there may be a region of invisibles; and that, could we draw aside the mysterious curtain which shrouds it from our senses, we might then see a theatre of as many wonders as astronomy has unfolded, a universe within the compass of a point so small as to elude all the powers of the microscope, but where the wonder-working God finds room for the exercise of all his attributes, where he can raise another mechanism of worlds, and fill and animate them all with the evidence of his glory."[1]

Although we cannot hope to derive the same amusement or advantage from the study of each of the animalcular species considered separately, as we do from the consideration of the history of many of the higher animals, yet, in a philosophical point of view, a knowledge of the general attributes of the class presents several highly important objects; and their obscure origin, their singular organization, and more singular mode of existence, cannot fail to excite our unfeigned wonder and admiration. They can scarcely be described otherwise than by a negation of all those characters which constitute the life, power, and activity of other beings; they have no head, no eyes, no muscles, no blood-vessels, no nerves, no determinate organs for respiration, generation, or digestion—and yet they are endowed with life.

The animal nature of the Infusoria has indeed been denied by many; but such is the regular gradation from the most simply organized of the monadal forms to the much

[1] Chalmers's *Astronomical Discourses*, p. 112.

more complicated structure of the Polypi, which present, under a remarkable aspect, such unequivocal characters of animality, that it is impossible to draw the line of demarcation; and if we admit the life of the one we can scarcely doubt that of the other. Yet many of the Infusoria appear to present the very lowest conceivable point to which animal life can be reduced.

The structure of an animal, the individual existence of which is preserved by the absorption of a circumambient fluid, and the continuance of whose species is effected by the division or separation of a part of its own body, might, *a priori*, be supposed to be of the most simple kind. "We may rest assured," observes Lamarck, "that whenever an organic function is itself unnecessary, the special organ by which it is usually performed will not be found to exist." It is indeed by considering the nature of the Infusoria that we are enabled to form a proper idea of the simplest condition of animal life; and the invention of the telescope was not of higher importance to the astronomer, than that of the microscope to the physiological naturalist. There are few subjects of reflection more interesting than the uses which philosophers of an enlightened age have deduced and matured from the scanty knowledge of a barbarous people. Glass, a material known at an early period to the Asiatic nations, and once estimated at its weight in gold, has become in the hands of Europeans of more value than the finest gold. Whoever polished the first lens may be said to have laid the foundation of an instrument destined to discover thousands of celestial worlds above and around us, and an unseen world of wonders beneath our feet. "Indeed," says Cuvier, "it could not be expected that those Phœnician sailors who saw the sand of the shores of Bœtica transformed by fire into a transparent glass, should have at once foreseen that this new substance would prolong the pleasures of sight to the old; that it would one day assist the astronomer in penetrating the depths of the heavens, and in numbering the stars of the milky way; that it would lay open to the naturalist a miniature world as populous, as rich in wonders, as that which alone seemed to have been granted to his senses and his contemplation; in fine, that the most simple and direct use of it would enable the inhabitants of the coast of the Baltic Sea to build palaces more magnificent than those of Tyre and Memphis, and to cultivate, almost under the frost of the polar circle, the most delicious fruits of the torrid zone."[1]

The faculties of the most simple infusory animals, it has been observed, are reduced to such as are common to all living beings, and to that *irritability* which results from their animal nature; and their bodies are destitute of special organs, precisely because their extremely limited faculties neither require nor admit of such organs being exercised. The chief interest to be derived from the study of this class of beings results, according to Lamarck, from the view with which such study presents us of the ultimate point to which the organization of an animal is capable of being reduced; and, among all the wonders of the creation, he regards as the most surprising the existence of animal life in such inconceivably frail and simple bodies as the least complicated of the animalcular species. It is not, however, to be said that "nature was incapable of forming special organs from the materials of these frail gelatinous bodies," but rather that the all-wise Author and Ruler of Nature has seen fit to form them in what to us may appear a destitute and incomplete condition, merely because their structure does not fulfil those other conditions which, erroneously, we have sought to establish as the indispensable bases of animal life. They truly show how confined a knowledge *our* limited faculties enable us to gain of His unlimited power; for they not only present no analogy to other more accustomed forms of life, but almost seem to exist in direct opposition to those laws in accordance with which we "live, move, and have our being."

Infusory animals, commonly so called, are found in the fresh and saline waters of all countries. They occur both naturally, if we may use the term in a contradistinctive sense, and as the apparent result of infused animal and vegetable substances. According to Leeuwenhoeck, the milt of a cod-fish contains more animalcules than there are individuals of the human race existing on the face of the earth; and he calculated that 10,000 might be held within the bulk of a grain of sand. The size of many bears the same relation to that of a mite as the dimensions of a bee do to those of an elephant; and the most powerful microscopes frequently discover nothing more than merely perceptible points in motion. Flour and water made to the consistence of book-binders' paste, exposed in an open vessel, and frequently stirred to prevent the surface from growing hard, will in a few days be found to contain millions of animalcules. The thin pellicle which grows on the surface of an infusion of common black pepper also produces an innumerable congregation of minute beings. Of these and others the real origin is still exceedingly obscure; and both Müller and Spallanzani maintained the improbable opinion that they fell from the air. Their subsequent increase or multiplication is obviously effected in different and very singular ways. Such as are spherical are usually propagated by minute portions, which, though they burst from the anterior of the animalcule itself, cannot be called eggs; and such as are of a depressed or flattened form continue their race by *cuttings* or divisions of their own bodies. We first observe a line or groove, longitudinal or transverse, according to the species; and ere long a notch or incision is perceptible at one or other or both of the ends of that apparent line. This notch increases across or longitudinally, till at last a portion is separated or cut off, or the original animal is divided into two, and each assumes the form and nature of their mutual predecessor. These new objects retain for some time their natural shape, and then in their turn give rise to one or more individuals by a similar separation of parts. Lamarck seems to be of opinion (*Philosophie Zoologique*, tome ii. p. 120 and 150) that this multiplication by division, and that by the emission of gemmules or oviform portions, are modifications of one and the same natural process;—that substantially each is the result of an extension and separation of parts, which take place when the parent individual has reached the final term of its increase. It is in fact the same excess of nourishment and growth of particular parts that, even in the higher classes, give rise to the germ of separate life, physically considered, although in regard to these the additional process of fecundation is required. It is the new light which may be gathered from the observation of the minutest of the animalcular tribes that renders their study both interesting and important to the physiologist; and it is the belief of some, that a persevering study of the history of microscopical animals will one day enable us to withdraw the mysterious veil which still conceals from our view the most important secrets of nature.

The systematic arrangement of animalcules which we propose to follow in this place is nearly that of Lamarck,

[1] *Réflexions sur la Marche actuelle des Sciences*, &c. read to the Institute of France in April 1816.

Animalcule.

which is itself founded on the systems of Müller and Bruguière. The French naturalist includes in his system only such species of the same class described by Müller as are destitute of a mouth.

Order I.—Naked Infusoria.

Body extremely simple, apparently homogeneous, unprovided with organs or external appendages.

The naked Infusoria are the smallest and simplest of those animals which are cognizable by the senses of man. When we expose water to air and light, especially if it contains an infusion of animal or vegetable remains, we speedily perceive, by the assistance of the microscope, a variety of animalcules. These are divided into two sections.

Section I.—Body Thick.

Of this section the bodies present such a perceptible degree of thickness as removes them from the simply membranous state.

Genus Monas.—Body extremely small, of the simplest construction, transparent, punctiform.

The Monads are the smallest and least organized of living creatures. We have indeed scarcely any proof of their animal life, except that they are moving corpuscles, allied to the genus Volvox, the animality of which is undoubted. They have neither mouth nor alimentary canal, nor any apparent organs. They live by absorption, and are found in tranquil, but rarely in limpid waters. They are produced in infusions of animal and vegetable substances.

Sp. 1. *Monas termo.*—An extremely minute gelatinous point, scarcely perceptible even with the aid of a powerful lens, and frequently disappearing under a strong light in consequence of its perfect transparency. This species is common in ditch-water, and in numerous infusions. See Plate XLVI. fig. 1. These minute creatures being the earliest discernible evidence of animal life, and the last result to which the higher and more perfect forms can be reduced by infusion, have been called the alpha and omega of all organized existence. Their history has given rise to many curious views, and more absurd speculations.

Sp. 2. *Monas atomus.*—White, with a variable dark-coloured spot, which appears to change its position. This species was found in sea-water which had been kept an entire winter, but was not very fetid. See Plate XLVI. fig. 2 and 3.

Sp. 3. *Monas punctum.*—Nearly black, of a sub-cylindrical form. Found in the infusion of the pulp of a pear.

Sp. 4. *Monas lens.*—Hyaline, of an ovoid form. Found in all kinds of waters. Multiplies by spontaneous incision.

Sp. 5. *Monas pulvisculus.*—Hyaline, with a greenish margin. Found in the waters of marshes. This species has been lately regarded as an *enchelis.* Indeed, so great is the difficulty of microscopical investigation, and such indefatigable patience is required in order to see things as they really are, that the species and genera of this class of beings are frequently transposed and altered in their relative position and arrangement, in consequence of the very dissimilar views which different observers have taken of the same object.

As it would be inconsistent with our present limits to describe more than a few species of each genus, we shall content ourselves with the preceding Monads. "How many kinds," observes Mr Adams, "there may be of these invisibles, is yet unknown, as they are discerned of all sizes, from those which are barely invisible to the naked eye, to such as resist the force of the microscope, as the fixed stars do that of the telescope, and, with the greatest powers hitherto invented, appear only as so many moving points."

Genus Volvox.—Body very simple, transparent, spherical or ovoid, revolving on itself as on an axis.

With the exception of one species (*V. globator*) the volvoces are invisible to the naked eye. Under the microscope they assume the aspect of small gelatinous masses, which sometimes present an oval form. In some the body seems composed of numerous smaller globules united in one common mass. There is reason to suppose that these interior bodies are afterwards propelled outwardly, and become separate individuals. The species occur both in fresh and salt waters, and in vegetable infusions. They derive their generic name from the manner in which they turn or revolve upon their axis. Leeuwenhoeck describes an animalcule "a thousand times smaller than a louse's eye, which exceeded all the rest in briskness," and turned itself round as it were upon a point, with the celerity of a spinning-top. The genus is divisible into two sections.

* *Interior of the body apparently simple and homogeneous.*

Sp. 1. *Volvox punctum.*—Spherical, blackish, with a central lucid point. Of this species many are sometimes seen together in their passage through the water. They occasionally move as if subjected to the influence of a whirlpool, and then separate. Numerous in fetid sea-water.

Sp. 2. *Volvox granulum.*—Spherical, green, periphery hyaline. Dwells in the water of marshes.

Sp. 3. *Volvox globulus.*—Globular, sub-obscure behind. This species is ten times larger than the Monas lens. It occurs in most vegetable infusions, and moves with a slow fluttering motion. Plate XLVI. fig. 4.

* * *Interior of the body exhibiting smaller corpuscles.*

Sp. 4. *Volvox pilula.*—Spherical, with greenish internal globules. In those pure waters which nourish the *Lemna minor.* Plate XLVI. fig. 5.

Sp. 5. *Volvox lunula.*—Roundish and transparent, and composed of an innumerable assemblage of homogeneous crescent-shaped molecules, without any common margin. Its movements are of two kinds, that of the molecules among themselves, and that of the whole revolving mass. It occurs in marshy places in the early spring. Plate XLVI. fig. 6.

Sp. 6. *Volvox globator.*—Commonly called the globe-animal. Spherical, membranous, the internal globules distant or scattered. Abundant in the infusions of hemp and tremella, and in stagnant pools during spring and summer. The following is an account of it by Mr Baker. "There is no appearance of either head, tail, or fins, and yet it moves in every direction, backwards, forwards, up or down, rolling over and over like a bowl, spinning horizontally like a top, or gliding along smoothly without turning itself at all; sometimes its motions are very slow, sometimes very swift; and, when it pleases, it can turn round as upon an axis very nimbly, without moving out of its place. The body is transparent, except where the circular spots are placed, which are probably its young." Another authority states that this species is at first very small, but increases to such a size that it may be discerned by the naked eye, and that its interior is filled with small globules, which are smaller animalcules, each of which contains within itself a still smaller generation, all perceptible by means of powerful glasses. The lesser globules may be seen escaping from the parent, and increasing in size.

ENUS PROTEUS.—Body very small, simple, transparent, of varying form, changing itself instantaneously into different lobated shapes.

This genus is more obviously contractile than the preeding. It is seldom seen above a minute under the same orm, but is continually passing from a simple oval or obong to an irregular or sinuated shape, and *vice versa.* species described by Roësel is so remarkable for this iculty, that it has been compared to a drop of water rown upon oil. Hence also the generic name.

Sp. 1. *Proteus diffluens.*—Body diverging into branches. ccurs in the water of marshes. Plate XLVI. fig. 7, 8, nd 9.

Sp. 2. *Proteus tenax.*—Body prolonged to a fine point. ccurs in rivers and in sea-water. There are only two pecies described as belonging to this genus.

ENUS ENCHELIS.—Body very small, simple, oblong, cylindrical, slightly variable.

There is a marked analogy between this genus and the llowing. The Enchelides are, however, short and thick ompared with the Vibriones, which are slender and ngthened. To the genus now under consideration beong those animals which, if the recorded observations on e subject have been accurately made and faithfully reorted, more than any other confound our preconceived leas regarding the distinction between animal and vegeible life. The species alluded to are named *Zoocarpes* by I. Bory de St Vincent, or animated seeds, which appear reprocally to give rise to and proceed from certain aquatic lants of the confervæ kind. They are formed in a bulbus-shaped part or swelling of the plant, are ejected when pe, swim about for some time with a voluntary motion, row out a root and a branch, become genuine vegetables, roduce living seeds, and give birth to animals which, afr a similar change of form, speedily return again to the egetable state. These facts are vouched for by M. Bory de t Vincent, and are credited and confirmed by M. Dutrochet nd several other continental inquirers, some of whom eclare that they kept so watchful an eye upon the same dividual as never to lose sight of it for a moment till ey had witnessed the singular transformation above entioned. We recommend it to our readers' consideration.

Sp. 1. *Enchelis viridis.*—Subcylindrical, obliquely truntated anteriorly. This species has an obtuse tail or terinal part. It continually varies its motion, turning from ght to left. Occurs in long-kept water.

Sp. 2. *Enchelis punctifera.*—Subcylindrical, green, obse anteriorly, pointed posteriorly. This species is opaque, ith a small pellucid spot in the fore part, in which two lack points are seen, and a kind of double band crosses e middle of the body. It occurs in marshes. Plate LVI. fig. 10, 11.

Sp. 3. *Enchelis pulvisculus.*—This species bears a great esemblance to the *Monas pulvisculus* of Müller, which the *E. monadina* of Bory de St Vincent. It is, howver, double the size, deeper tinted, and more ovoid. t is found in the waters of marshes, and accumulates round the sides of jars or vases in which confervæ have een kept. It forms on the surface of water a slight ellicle of a delicate green colour, which is supposed to ave been erroneously regarded by many botanists as a egetable production, and described under the name of *Byssus flos aquæ.* On dying it becomes more lengthened nd pellucid, or at least retains only a slight central spot f green. Plate XLVI. fig. 12.

Sp. 4. *Enchelis amœna.*—This is a new species, of a vely green colour, discovered by Bory de St Vincent. In wimming it appears to elongate itself, and advances with the more slender end foremost. Two individuals are sometimes observed to unite and form one animal, of a perfectly spherical form, and similar in aspect to a Volvox.

Sp. 5. *Enchelis tiresias.*—This species was also discovered by the above-named writer, and led to his peculiar views regarding those apparently animated seeds which he has named *Zoocarpes.* He asserts that he has seen this animalcule formed in the articulations of a true conferva; that it burst from its vegetable envelope with a gyration or circular movement; that it soon produced a translucent prolongation of its body, which may be called anterior, as it then swam in the direction of that new organ, which, with the body itself, became visibly longer, till the creature finally acquired the exact form of the *Enchelis deses* of Müller. The chief difference seemed to be that it always moved with the slender end foremost, whereas the species just mentioned swims with its blunt end in advance. It is described by recent French writers as an "animal extraordinaire qui n'est certainement que la grain vivante d'un végétal." (See *Dict. Class. d'Hist. Nat.* tome vi. p. 156.)

Sp. 6. *Enchelis deses.*—This species is of an obscure green, much elongated, and moves with the thick end anteriorly. "Celui-ci (the obtuse portion) paraît comme tronqué dans certains aspects; et en examinant attentivement cette sorte de troncature, on la réconnaît formée par un cercle en forme de disque moins foncé que le reste de l'animal. La pointe postérieure est parfaitement hyaline. Dans la pensée où nous sommes que les Enchelides vertes ne sont que des Zoocarpes, ou propagules animés de quelques genres d'Arthrodiées, nous croyons que le disque obscurément transparent de la partie antérieure n'est que la marque du point sur lequel doit se développer l'article par lequel doit s'allonger en filament confervoïde le Zoocarpe, lorsque, arrivé au terme de sa carrière animale, il doit se fixer et prendre racine par le point hyalin de la partie postérieure." (*Loc. cit.* p. 157.) We present the above passage to our readers without note or comment, as we do not ourselves understand the zoocarpal nature of an Enchelis.

GENUS VIBRIO.—Body very small, simple, cylindrical, elongated.

Animalcules have been described as constituents of this genus, which probably do not at all belong to it, being too complicated in their structure. If the *V. aceti*, for example, commonly called the vinegar eel, is furnished with a mouth, lips, and alimentary canal, it does not even pertain to the class Infusoria, however small its dimensions. But many of the species are undoubtedly of the simplest construction; and although they may present some appearance of an internal cavity or sac, they yet exhibit neither mouth nor other external orifice of any kind.

Sp. 1. *Vibrio lineola.*—Body linear, extremely minute. Occurs in many vegetable infusions in such numbers as apparently to occupy their entire space. It is so small, that with the best magnifiers little more can be discerned than an obscure tremulous motion. It is supposed to exceed even the *Monas termo* in tenuity. Plate XLVI. fig. 13.

Sp. 2. *Vibrio spirillum.*—Filiform, and twisted spirally, which seems to be its natural shape, as it is never observed to unbend, but moves forwards with a vibratory motion at both ends. Found in an infusion of *Sonchus arvensis.* Plate XLVI. fig. 14.

Sp. 3. *Vibrio vermiculus.*—Presents a milky aspect, with a blunt apex, and moves with a languid vermicular motion. It has been found in marshy water in November, but is seldom seen. It agrees with the animal mentioned by Leeuwenhoeck as occurring in the dung of frogs.

Sp. 4. *Vibrio paxillifer.*—"Animalculum," says Mül-

Animalcule.

ler, "vel congeries animalculorum mirabilis. Pluries in guttulis aquæ marinæ vidi corpuscula linearia flavescentia (solitaria paleas, in quadrangula disposita scobes referebant), granulaque seminalia qualiscunque vegetabilis diu credidi; demum nocte inter 6 et 7 Octobrem 1781 aspectu fili flavescentis, sese in longum producentis et in breve contrahentis, ac ex his paxillis compositi, obstupefactus, novoque phænomeno gavisus, ejusdem variis evolutionibus incubui." A salt-water species, abundant in ulva latissima. Observed during the months of September and October. Plate XLVI. fig. 15, 16, 17, 18, 19.

Sp. 5. *Vibrio serpens.*—Slender and gelatinous, with obtuse windings or flexures, resembling a serpentine line. It is rare, and occurs in river-water.

SECTION II.—BODY MEMBRANACEOUS.

Of scarcely perceptible thickness, whether flat or concave.

The organization of the animalcules of this section is scarcely less simple than that of the preceding; but their form, being in a small degree resistant, is less subject to variation from the pressure or other action of the surrounding fluids, which has been regarded as the proof of a certain progress or advance in the scale of structure.

GENUS GONIUM.—Body very small and simple, flattened, short, angular. Some species of this genus appear to be composed of several corpuscles united together under a common membrane. This appearance probably results from their cellular tissue, or from certain lines which are the rudiments of those spontaneous divisions formerly mentioned, by which their propagation is affected. Their movements are oscillatory.

Sp. 1. *Gonium pectorale.*—Quadrangular and pellucid, with sixteen globules of a greenish colour set in a quadrangular membrane, "like jewels in the breast-plate of the high-priest, reflecting light on both sides." Occurs in pure waters. Plate XLVI. fig. 20.

Sp. 2. *Gonium pulvinatum.*—Quadrangular and opaque. Found in dunghills.

Sp. 3. *Gonium corrugatum.*—Sub-quadrangular, whitish, marked by a longitudinal line. This species is found in various infusions, particularly that of the pear.

Sp. 4. *Gonium truncatum.*—Internal molecules dark green. Anterior extremity forming a straight line, with which the sides produce an obtuse angle, terminated posteriorly by a curved line. This species exhibits a languid motion. It is much larger than the preceding, and occurs, though rarely, in pure water.

GENUS CYCLIDIUM.—Body very small and simple, transparent, flattened, orbicular or oval.

The motions of this genus are oscillatory, circulatory, or demi-circulatory, more or less interrupted, and languid or lively, according to the species.

Sp. 1. *Cyclidium bulla.*—Orbicular and hyaline. General appearance pale and pellucid, with the edges somewhat darker than the rest. It moves slowly in a semicircular direction, and occurs in the infusion of hay.

Sp. 2. *Cyclidium hyalinum.*—Oval, depressed, perfectly transparent, terminated by a tail-like elongation. This species is very common, and is produced in many infusions, particularly in those of the cerealia. It swims in a vacillating manner, and as if continually trembling. Plate XLVI. fig. 21.

Sp. 3. *Cyclidium Nucleus.*—Of a brownish tinge, deeper behind, and shaped exactly like an apple pippin.

GENUS PARAMÆCIUM.—Body very small, simple, transparent, membranous, oblong.

The species of this genus, according to Lamarck, scarcely differ from those of the preceding, except in their more lengthened forms and a slight increase of animal development. They appear to vary instantaneously according to their position in relation to the eye of the observer; but their real form is tolerably determinate. The mode of increasing the species by transverse and longitudinal divisions, or natural cuttings, is very obvious in this genus. They are nearly related to the following, but are less sinuous and irregular. Their movements are for the most part slow and indefinite. They swim horizontally on one of their flattened surfaces, after the manner of flounders.

Sp. 1. *Paramæcium aurelia.*—Body compressed, with a kind of plait or fold towards the apex, acute behind. Very common in water where confervæ grow. Plate XLVI. fig. 22, 23, 24.

Sp. 2. *Paramæcium chrysalis.*—Plicated anteriorly, obtuse behind. Occurs during the autumn in sea-water.

Sp. 3. *Paramæcium versutum.*—Cylindrical, thickened posteriorly, obtuse at both ends. Found in ditches.

GENUS KOLPODA.—Body very small, simple, flattened, oblong, sinuous, irregular, transparent.

This genus is nearly allied to the preceding, and differs from it chiefly in its more varied forms. It is also less subject to the influence of pressure by the medium in which it lives. An Italian naturalist of the name of Losana has lately published a monograph on Kolpoda; but his figures are somewhat exaggerated, and not very naturally expressed.

Sp. 1. *Kolpoda lamella.*—Elongated, membranaceous, curved anteriorly. This species is seldom met with. It has a singular vacillatory mode of movement, and advances on its sharp edge, instead of its flattened side, the more usual position.

Sp. 2. *Kolpoda gallinula.*—Oblong, the anterior portion of the back membranaceous and hyaline. In corrupted sea-water.

Sp. 3. *Kolpoda crassa.*—Yellow, thickish, somewhat opaque, curved a little in the centre, kidney-shaped. This species has a quick vacillatory motion, and becomes apparent in the infusion of hay generally in about 13 hours. When the water is nearly evaporated it assumes an oval form, becomes compressed, and bursts.

Sp. 4. *Kolpoda rostrum.*—Oblong, hooked anteriorly. The movements of this species are slow and horizontal. It is found, but not frequently, in water where the lemna grows.

Sp. 5. *Kolpoda cucullus.*—Ovate, ventricose, the top bent into a kind of beak, and an oblique incision beneath the apex. This species is found in vegetable infusions, and in fetid hay, and usually moves with great velocity. It is pellucid, and appears as if filled with little bright vesicles, which differ in size. Some have supposed them to be lesser animalcules which the Kolpoda has swallowed; but as it has no mouth wherewith to swallow, Müller is more probably right in regarding them in the light of germs. When about to die in consequence of evaporation, it protrudes its contents, whether food or offspring, with great violence. Plate XLVII. fig. 25, 26, 27, 28.

GENUS BURSARIA.—Body simple, membranaceous, concave.

This genus occurs in fresh, saline, and stagnant waters. It appears to vary its form beneath the eye of the observer, and, from a rounded flattened shape, assumes a concave or somewhat purse-shaped aspect.

Sp. 1. *Bursaria truncatella.*—Follicular, with a truncated apex. This species is visible to the naked eye. It moves from left to right, and from right to left; ascends to the surface in a straight line, and sometimes rolls about as it descends.

Sp. 2. *Bursaria bulina.*—Boat-shaped, labiated anteriorly. This species is pellucid and crystalline, with brilliant globules within it. It is concave on the upper side, and convex below.

Sp. 3. *Bursaria hirundella.*—With two small wing-like projections, which give it somewhat of the appearance of a bird. It is invisible to the naked eye, but appears under the microscope like a pellucid hollow membrane. Recent micrographical observers doubt if this species really pertains to the present genus. Plate XLVII. fig. 29.

ORDER II.—APPENDICULATED INFUSORIA.

Furnished exteriorly with projecting parts.

The animalcules of this second principal order or division, though still infinitely small, gelatinous, and transparent, are so far less simply organized than their predecessors, inasmuch as they are furnished with salient parts, such as hairs, horns, or tail-like appendages, or at least with such projecting organs as, for want of more appropriate terms, we are obliged to designate by those names. They multiply both by division and by the bursting forth of internal germs. Though their essential fluids, and the living tissue which contains them, are probably of more compound nature than those of the naked Infusoria, they have not yet reached that point of organization in which special organs are developed for the performance of particular functions; and it is not till we reach the higher class of Polypi that these are distinctly perceptible.

"Il paraît," observes Lamarck, "par les nombreuses espèces déjà connues et publiées, que les Infusoires de cet ordre sont bien plus nombreux dans la nature que les Infusoires nus. Cela doit être ainsi d'après les principes que je me suis cru fondé à établir.

"En effet, dans les Infusoires nus, l'origine encore trop récente des races qui proviennent de celles, en petit nombre, qui furent générées spontanément, n'a permis à la durée de la vie et aux circonstances qui ont influé sur ces races, qu'une diversité peu considérable. Mais à mesure que la durée de la vie, que sa transmission dans les individus qui se sont succédés en se multipliant, et que les circonstances ont eu plus de temps pour exercer leurs influences, les races se sont diversifiées de plus en plus, et sont devenues plus nombreuses.

"Cet ordre des choses, qu'il est facile de reconnoître pour celui même de la nature, nous fait sentir pourquoi les *Infusoires* sont bien moins diversifiés et moins nombreux que les *Polypes*. Effectivement, quoique nous ne connaissions pas probablement tous les Infusoires, et que nous connaissions bien moins encore tous les Polypes, ce qui est déjà connu de part et d'autre indique que la diversité des Polypes est considérablement plus grande que les Infusoires. Aussi les Polypes sont plus éloignés de leur origine que les Infusoires." (*Animaux sans Vertèbres*, tome i. p. 433.)

The first genus of this order (*Trichoda*), as constituted by Müller, contains several species which manifest the rudiments of a mouth and the commencement of an alimentary canal: these, according to the negative characters of the class, do not belong to the Infusoria.

GENUS TRICHODA.—Body very small, transparent, diversiform, without caudal appendage, but garnished with soft hairs either on the whole or on part of its surface.

According to the views of Lamarck, this genus contains not only a great proportion of the genus *Trichoda* of Müller, but also the whole of the genus *Leucophra* of the Danish author. It is distinguished from *Kerona* by the want of the long, stiff, distant, corniform hairs which characterize the latter.

A. *Body ciliated over its entire surface.*

(Leucophra of Müller.)

Sp. 1. *Trichoda viridiscens.*—Greenish, cylindrical, opaque, thicker posteriorly. Found in sea-water.

Sp. 2. *Trichoda dilata.*—Body flattened, variable, with sinuated margins. Inhabits sea-water, and swims like a *Planaria*. It scarcely differs from the genus *Kolpoda*, except in being ciliated.

Sp. 3. *Trichoda scintillans.*—Of a green colour, oval, slender, and opaque. Occurs in stagnant water. A doubtful species, closely allied to *Volvox*.

Sp. 4. *Trichoda acuta.*—Ovate, with a sharpened point. Colour yellowish. Of this species the form is very variable. It occurs in sea-water among ulvæ. Plate XLVII. fig. 30, 31, 32.

Sp. 5. *Trichoda signata.*—Oblong, sub-depressed, with a blackish margin. Common in sea-water. This species is distinguished by a curved line in its centre, shaped like the letter *S*, one end of which sometimes assumes a spiral form.

Sp. 6. *Trichoda mammilla.*—Spherical, opaque, with an exsertile papilla. Occurs in the waters of marshes. It is of a dark colour, its short hairs are curved inwards, and it occasionally appears to project and draw in a little white protuberance.

B. *Body ciliated, or covered with short hair only over a part of its surface.*

(The greater proportion of the genus Trichoda of Müller.)

Sp. 7. *Trichoda grandinella.*—Spherical, pellucid, haired above. The minute ciliary appendages of this species are not easily discovered, as it seems to possess the power of withdrawing them at pleasure and instantaneously. It occurs both in pure water and that of infusions.

Sp. 8. *Trichoda cometa.*—Spherical, ciliated anteriorly, with one or more globular appendages behind. Found in pure water in the autumnal season. Plate XLVII. fig. 33, 34.

Sp. 9. *Trichoda solaris.*—Spherical and crystalline, its edges beset with diverging rays, which exceed in length the diameter of the body. This animalcule contracts and dilates, but is stationary in the same spot. In marine infusions. Plate XLVII. fig. 35.

Sp. 10. *Trichoda pubes.*—Oval oblong, gibbous, depressed anteriorly. The apex of this species is furnished with hairs, which are seldom visible till it is about to expire, when it protrudes and extends them vehemently, as if in a vain attempt to secure and detain a remaining particle of water.

Sp. 11. *Trichoda proteus.*—Oval, obtuse behind, with an elongated retractile neck. Apex haired. This species, according to Müller and Lamarck, is found in river water. It appears, however, to agree in general character and appearance with the *Proteus* described by Mr Baker, which usually occurs in the slimy matter adhering to the sides of vessels in which either animal or vegetable substances have been some time kept. That of which an account is given by Mr Adams was found in the slime produced by water containing small fishes, snails, &c. The body was something similar to that of a snail, but pointed at one end, while from the other proceeded a long, slender, "and finely proportioned neck, of a size suitable to the rest of the animal." If we credit Mr Baker, this animalcule, though its eyes are not discernible, plainly demonstrates by its actions that it can see; for though multitudes swim about in the same water, and its own progressive motion is

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very swift, it never strikes against its neighbours, but directs its course with a dexterity "wholly unaccountable should we suppose it destitute of sight." Its entire shape bears a resemblance to that of a swan. See Plate XLVII. fig. 36 and 37. When alarmed, it draws in its supposed neck, becomes more opaque, and moves about slowly with the large end foremost. See fig. 38. After continuing for some time under this form, it will put forth a kind of wheel machinery, the motions of which are alleged to draw a current of water towards it from a considerable distance. After frequently pushing out and pulling in this shorter head, sometimes with and sometimes without the wheel-work, it will remain motionless, as if wearied or worn out; and then its long head and neck or apex will be again slowly protruded, after which it generally resumes its accustomed agility.

Genus Kerona.—Body very small, diversiform, without tail-like prolongation, and furnished with scattered, stiff, corniform hairs on some parts of its body.

To this genus Lamarck has united the Himantopus of Müller. The species are rare. They seldom occur in infusions, and are most frequent in the purer kinds of fresh and salt waters.

Sp. 1. *Kerona rostellum.*—Orbicular and membranaceous; one side angulated, the other furnished with a series of triple horns. Inhabits sea and river water. This species is alleged by Bory de St Vincent to be entirely destitute of hairs and cirri, and he therefore proposes to remove it to the order *Gymnodes*, which corresponds with our first order, the naked Infusoria. It is sometimes difficult to identify species in this department, or to ascertain, in a doubtful or contested case, that the same animalcule has been the subject of observation by two or more disputants. Plate XLVII. fig. 39.

Sp. 2. *Kerona cypris.*—Somewhat pear-shaped, compressed, the front furnished with hairs or vibrating points, inserted beneath the edge, shorter behind, and partly extended straight forward, partly bent downwards. Motion retrograde. Inhabits fresh water.

Sp. 3. *Kerona ludia.*—Smooth, pellucid, full of small points, the fore part clubbed and a little bent, the hinder part narrow; the base obliquely truncated, and terminating in a tail stretched out transversely. The top of that part which may be called the head, and the centre of the back, are furnished with long hairs. When this animalcule is at rest, its tail is curled; when in motion it is drawn tight and extended upwards. The movements of this species are lively and diverting.

Genus Cercaria.—Body very small, transparent, diversiform, furnished with a distinct but very simple tail.

This genus, as constituted by Müller, contains many species which bear no natural relation to each other; but his characters are precise and definite, and strictly applicable to those species which now form the genus as limited by modern observers. They occur more rarely among animal and vegetable infusions than in running streams and the waters of marshes. Their movements are for the most part circular and very rapid. With the exception of a well-marked tail, their organization is in every other respect extremely simple. If a mouth and the rudiment of a stomach or alimentary canal exist in any of these animals, such characters would remove them not only from the genus Cercaria, but from the class Infusoria, as defined at the commencement of this treatise. *A fortiori*, the existence of eyes (a fact assumed by some inaccurate observers) in any of the animalcular species, would entirely alter their position and arrangement in the animal kingdom. We cannot do better than report the observations of the venerable Lamarck (himself unfortunately now deprived of sight) on this obscure subject:—"Ici, comme dans le genre suivant, l'on est exposé, d'après la petitesse extrême des individus, à rapporter à la classe des Infusoires des animaux qui, par leur organisation, appartiennent à d'autres points de l'échelle animale."

"Une bouche, quoique d'abord inaperçue, et conséquemment l'ébauche d'un sac alimentaire, peuvent exister dans certains de ces animaux, et dès-lors ils appartiennent au premier ordre des Polypes; mais des yeux, comme on en a supposé dans certains Cercaires, cela est impossible.

"Avant de dire que le fait lui-même vaut mieux que la raisonnement, il faut, 1*mo*, constater que les points que l'on a pris pour des yeux, en sont réellement, et qu'ils ont chacun un nerf optique qui se rend à une masse médullaire, centre de rapports pour des sensations; 2*do*, il faut ensuite établir positivement que des animalcules réellement pourvus d'yeux, sont néanmoins, par leur organisation, de la même classe que les Infusoires." (*Animaux sans Vertèbres*, tome i. p. 444.)

This genus forms the nucleus of the new family of Infusoria proposed by M. Bory de St Vincent under the name of *Cercariées*, and which contains in all seven genera, the names and nature of which will be seen by referring to the tabular view. Müller, who was not practically acquainted with the spermatic animalcules, was attracted by the resemblance which some of the Cercariæ bore to the figures of those organic molecules in the works of his predecessors. He did not, however, assert their identity; and probably perceived that, although in their general aspect and mode of movement they resembled each other, their peculiar and very different localities, and even the details of their structure, rendered it advisable that they should be assigned to separate genera.[1]

Sp. 1. *Cercaria inquieta.*—Changeable, convex, with a slender tail. This species occurs in salt water, and is remarkable for assuming a variety of different forms. It is sometimes oval, sometimes cylindrical, sometimes shaped like a sphere. Plate XLVII. fig. 40.

Sp. 2. *Cercaria gyrinus.*—Body of a rounded form, with an acuminated tail. In swimming, this animalcule moves its tail like a tadpole.

Sp. 3. *Cercaria lemna.*—Changeable, sub-depressed, with an annulated tail. The C. lemna varies the form of its body in a manner almost as singular as that exhibited by the *Proteus*, already described. The body is triangular, or oblong, or kidney-shaped. Its tail is at times thick, short, annulated; at others it is long, cylindrical, and without rings; and when stretched out it sometimes vibrates with such velocity as to appear double. A small pellucid globule, which Müller regarded as the mouth, is perceptible near the apex; and there are also two excessively minute black points, which, whatever they may really be, are by some called eyes. It advances slowly by a few steps or movements at a time, and frequently shakes and bends its tail, in which position it bears a great resemblance to a

[1] The following are the characters of the genus *Zoosperma*, as recently established: "Corps non contractile, ovoïde, très-comprimé, avec une queue setiforme, aussi longue ou beaucoup plus longue, implantée à la partie postérieure, qui est peu ou point amincie. Ce genre, dont nous possédons un très-grand nombre d'espèces, se compose d'animaux spermatiques." (*Dict. Class. d'Hist. Nat.* tome iii. p. 356.) The production and existence of these animals, their nature and uses, are still among the many inscrutable mysteries of nature.

lmna leaf in miniature. This animalcule exhibits an advanced organization. Plate XLVII. fig. 41, 42, 43.

Genus Furcocerca.—Body very small, transparent, rarely ciliated, furnished with a bipartite tail.

This terminal genus, according to the views of Lamarck, conducts us to the limits of the infusorial class, and we become thus more liable to deception in regard to the non-existence of a mouth than in the preceding genera. It is a dismemberment of the *Cercaria* of Müller, and probably contains many species which will be placed elsewhere when future and more continuous observation shall have thrown additional light upon their nature and attributes.

Sp. 1. *Furcocerca podura.*—Cylindrical, acuminated posteriorly. This species is pellucid, and seems to consist of a head, trunk, and tail, the first of which, in the view of some observers, "resembles that of a herring." It turns round as if upon an axis when it moves, and is usually found in the months of November and December, in places where the lemna abounds. The tail frequently, but not always, appears to be divided into two. One of Müller's figures of this species is probably erroneous. He represents it as covered with short hairs; whereas, to more recent observers, it appears perfectly smooth. Plate XLVII. fig. 44, 45.

Sp. 2. *Furcocerca viridis.*—Cylindrical, variable, divided and acuminated behind. Occurs in spring in ditches and standing pools. It frequently contracts its anterior and posterior portions, so as to assume a spherical form. It is difficult to determine the genus to which this species belongs. Lamarck is supposed to have erred in placing it where it now stands. In truth, the genus appears to have been rather established provisionally, than upon an assured and natural foundation. The varying forms of the species which it contains render it extremely difficult either to discern or describe them with precision. Plate XLVII. fig. 46, 47, 48.

We have now endeavoured to present a general view, and a systematic exposition, of the principal features of the animalcular world; and if our statements have been less explicit, and our arrangement less complete and methodical, than accords with the reader's expectation, these defects must in part be attributed to the uncertainty which still prevails regarding a subject of which many of the essential characters scarcely lie within the limits of human intelligence. The observations and experiments of the English microscopical observers of last century, though they might amuse the general student, are too vague and fanciful to be now regarded as parts of the assured history of animalcules. The ultra-analogical reasoning on subjects of natural science with which we have been lately favoured by such men as Oken and Geoffroy St Hilaire, are tame in comparison with the inferences deduced by some of our older observers, who describe with minuteness the head, eyes, mouth, jaws, throat, stomach, intestines, and other parts of animalcules, which the improved glasses of modern times do not reveal to the vision of not less patient inquirers. The recent observations on the motions of the pollen of plants, which have puzzled the modern philosophers, would have opposed but feeble barriers in the way of our predecessors. "To discover," says Buffon, "whether all the parts of animals, and all the seeds of plants, contained moving organic particles, I made infusions of the flesh of different animals, and of the seeds of more than twenty different species of vegetables; and after remaining some days in close glasses, I had the pleasure of seeing organic moving particles in all of them. In some they appeared sooner, in others later; some preserved their motions for months, and others soon lost it. Some at first produced large moving globules resembling animals, which changed their figure, split, and became gradually smaller; others produced only small globules, whose motions were extremely rapid; and others produced filaments, which grew longer, seemed to vegetate, and then swelled and poured forth torrents of moving globules." It was from these and similar observations that the theory arose proposed by Baron Munchausen (an ominous name!). The Baron perceiving that these moving globules, after taking a little exercise, began again to vegetate, drew the conclusion that they were first animals and then plants; thus anticipating by more than half a century the supposed discoveries of some modern physiologists. Which of them was first in error it is perhaps of little consequence to inquire; and we allude to the subject here rather in connection with some singular observations by Mr Ellis, recorded in the 59th volume of the *Philosophical Transactions*, than from its own intrinsic importance. His object was to overturn Munchausen's hypothesis, by showing that the supposed Zoocarpes were nothing more than "the seeds of that genus of fungi called *mucor* or *mouldiness*," and that their motions were caused by the attacks of myriads of animalcules! "Having at the request of Dr Linnæus made several experiments on the infusion of mushrooms in water, in order to prove the theory of Baron Munchausen, that these seeds are first animals and then plants, it appeared evidently that the seeds were put in motion by very minute animalcules, which proceeded from the putrefaction of the mushroom: for by pecking at these seeds, which are reddish, light, round bodies, they moved them about with great agility in a variety of directions; while the little animals themselves were scarcely visible till the food they had eaten had discovered them. The satisfaction I received from clearing up this point led me into many other curious and interesting experiments. The ingenious Mr Needham supposes these little transparent ramified filaments, and jointed or coralloid bodies, which the microscope discovers to us on the surface of most animal and vegetable infusions when they become putrid, to be zoophytes, or branched animals; but to me they appear, after a careful scrutiny with the best glasses, to be of that genus of fungi called *mucor* or *mouldiness*, many of which Michellius has figured, and Linnæus has accurately described. Their vegetation is so amazingly quick, that they may be perceived in the microscope even to grow and feed under the eye of the observer. Mr Needham has pointed out to us a species that is very remarkable for its parts of fructification (See *Phil. Trans.* vol. xlv. tab. 5, fig. 3, *a*, A). This, he says, proceeds from an infusion of bruised wheat. I have seen the same species proceed from the body of a dead fly, which was become putrid by lying floating for some time in a glass of water where some flowers had been, in the month of August 1768. This species of mucor sends forth a mass of transparent filamentous roots; from whence arise hollow stems, that support little oblong oval seed-vessels, with a hole on the top of each. From these I could plainly see minute globular seeds issue forth in great abundance, with an elastic force, and turn about in the water as if they were animated. Continuing to view them with some attention, I could just discover that the putrid water which surrounded them was full of the minutest animalcula; and that these little creatures began to attack the seeds of the mucor for food, as I have observed before in the experiment on the seeds of the larger kind of fungi or mushrooms. This new motion continued the appearance of their being alive for some time longer; but soon after many of them arose to the surface of the water, remaining there without

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motion; and a succession of them afterwards coming up, they united together in little thin masses, and floated to the edge of the water, remaining there quite inactive during the time of observation." In like manner, the movements of the jointed coralloid bodies which Mr Needham has named *chaplets* and *pearl necklaces* are attributed to the attacks of their animalcular enemies. "When a small portion of these branches and seeds are put into a drop of the same putrid water upon which the scum floats, many of these millions of little animalcula with which it abounds immediately seize them as food, and turn them about with a variety of motions, as in the experiments on the seeds of the common mushrooms, either singly, or two or three seeds connected together; answering exactly to Mr Needham's description, but evidently without any motion of their own, and consequently not animated!"

We shall conclude this subject with a short notice of another view of the matter, which has resulted from some recent experiments and observations by our celebrated botanist Robert Brown. While engaged in some inquiries regarding the structure of the pollen of plants, and its mode of action on the pistillum of phænogamous tribes, that accurate observer had occasion to immerse in water some particles taken from the full-grown anthers (previous to bursting) of *Clarkia pulchella*. Of these, he perceived by the microscope that many were evidently in motion, and that their motion consisted not only of a change of place in the fluid, but of a change of form in themselves; that is to say, a contraction or curvature about the middle of one side, accompanied by a corresponding enlargement or convexity on the other, frequently occurred. The particles were seen, in a few instances, to turn on their longer axis; and their general motions were of such a nature as to produce the conviction in Mr Brown's mind that they did not arise either from currents or evaporation of the fluid, but were proper to the particles themselves. Having ascertained that motion existed in the pollen of all the living plants which he examined, he next inquired whether, and for what length of time, this singular property was retained after the death of the plant. Specimens were experimented on, which had been dried and preserved in an herbarium for 100 years, and the moving molecules or small spherical bodies were still perceived in considerable numbers. "The very unexpected fact," says Mr Brown, "of seeming vitality retained by those minute particles so long after the death of the plant, would not perhaps have materially lessened my confidence in the supposed peculiarity; but I at the same time observed, that on bruising the ovula or seeds of Equisetum, which at first happened accidentally, I so greatly increased the number of moving particles, that the source of the added quantity could not be doubted. I found also, on bruising first the floral leaves of mosses, and then all other parts of those plants, that I readily obtained similar particles, not in equal quantity indeed, but equally in motion. My supposed test of the male organ was therefore necessarily abandoned. Reflecting on all the facts with which I had now become acquainted, I was disposed to believe that the minute spherical particles or molecules of apparently uniform size, first seen in the advanced state of the pollen of Onagrariæ, and most other phænogamous plants,—then in the antheræ of mosses, and on the surfaces of the bodies regarded as the stamina of Equisetum,—and, lastly, in bruised portions of other parts of the same plants,—were in reality the supposed constituent or elementary molecules of organic bodies, first so considered by Buffon and Needham, then by Wrisberg with greater precision, soon after and still more particularly by Müller, and very recently by Dr Milne Edwards, who has revived the doctrine, and supported it with much interesting detail. I now, therefore, expected to find these molecules in all organic bodies; and accordingly, on examining the various animal and vegetable tissues, whether living or dead, they were always found to exist; and merely by bruising these substances in water, I never failed to disengage the molecules in sufficient numbers to ascertain their apparent identity in size, form, and motion, with the smaller particles of the grains of the pollen. I examined also various products of organic bodies, particularly the gum raisins, and substances of vegetable origin, extending my inquiry even to pit-coal; and in all these bodies molecules were found in abundance. I remark here also, partly as a caution to those who may hereafter engage in the same inquiry, that the duct or soot deposited on all bodies in such quantity, especially in London, is entirely composed of these molecules. One of the substances examined was a specimen of fossil wood, found in Wiltshire oolite, in a state to burn with flame; and as I found these molecules abundantly and in motion in this specimen, I supposed that their existence, though in smaller quantity, might be ascertained in mineralized vegetable remains. With this view, a minute portion of silicified wood, which exhibited the structure of coniferæ, was bruised, and spherical particles, or molecules in all respects like those so frequently mentioned, were readily obtained from it; in such quantity, however, that the whole substance of the petrifaction seemed to be formed of them. But hence I inferred that these molecules were not limited to organic bodies, nor even to their products. To establish the correctness of the inference, and to ascertain to what extent the molecules existed in mineral bodies, became the next object of inquiry. The first substance examined was a minute fragment of window-glass, from which, when merely bruised on the stage of the microscope, I readily and copiously obtained molecules, agreeing in size, form, and motion, with those which I had already seen. I then proceeded to examine, and with similar results, such minerals as I either had at hand or could readily obtain, including several of the simple earths and metals, with many of their combinations. Rocks of all ages, including those in which organic remains have never been found, yielded the molecules in abundance. Their existence was ascertained in each of the constituent minerals of granite, a fragment of the sphinx being one of the specimens examined. To mention all the mineral substances in which I have found these molecules would be tedious; and I shall confine myself, in this summary, to an enumeration of a few of the most remarkable. These were both of aqueous and igneous origin, as travertine, stalactites, lava, obsidian, pumice, volcanic ashes, and meteorites from various localities. Of metals I may mention manganese, nickel, plumbago, bismuth, antimony, and arsenic. In a word, in every mineral which I could reduce to powder sufficiently fine to be temporarily suspended in water, I found these molecules more or less copiously; and in some cases, more particularly in siliceous crystals, the whole body submitted to examination appeared to be composed of them."

There were three points of importance which Mr Brown was anxious to ascertain regarding these molecules, viz. their form, whether they were of uniform size, and their absolute magnitude. He seems, however, not to have been entirely satisfied with his determination on any of these points. As to form, he states the molecules to be spherical. His manner of estimating the absolute magnitude and uniformity of size of the molecules found in the various bodies submitted to examination, was by placing them on a micrometer divided to five thousandths of an inch, the lines of which were very distinct; or, more rare-

, on one divided to ten thousandths, with fainter lines, not adily visible without the application of plumbago, as em-oyed by Dr Wollaston, but which in this case was inad-issible. The results can only be regarded as approxi-ate, but Mr Brown is disposed to believe that the mole-cule is of uniform size, though, as existing in various sub-stances, and examined in circumstances more or less favourable, he regards it necessary to state that its dia-meter appeared to vary from $\frac{1}{13000}$th to $\frac{1}{20000}$th of an inch.[1] (T.)

ANIMATED, or ANIMATE, in a general sense, denotes omething endowed with animal life.

ANIMATION signifies the communication of life to an imal body. The different hypotheses of physicians and ilosophers concerning the time of animation have had eir influence on the penal laws made against artificial portions; it having been made capital to procure miscar-age in the one state, while in the other it was only deem-l a venial crime. The emperor Charles V., by a consti-ution published in 1532, put the matter on another foot-g: instead of the distinction of an animated and unani-ated fœtus, he introduced that of a vital and non-vital etus, as a thing of more obvious and easy decision, and ot depending on any system either of creation, traduc-on, or infusion. Accordingly a fœtus was formerly said, a legal sense, to be animated when it was perceived to ir in the womb; but this doctrine is exploded, animation eing now dated from the moment of conception.

ANIME, in *Heraldry*, a term used when the eyes of a pacious creature are borne of a different tincture from e creature itself.

ANIME, a resin exuding from the trunk of a large Ame-can tree, called by the Indians *courbaril* (a species of YMENÆA). This resin is of a transparent amber colour, light agreeable smell, and little or no taste. It dis-lves entirely, but not very readily, in rectified spirit wine; the impurities, which are very often in large uantity, remaining behind. The Brazilians are said to nploy anime in fumigations for pains and aches proceed-g from cold: with us, it is rarely, if ever, made use of r any medicinal purpose.

ANIMETTA, among ecclesiastical writers, denotes the oth wherewith the cup of the eucharist is covered.

ANINGA, in *Commerce*, a root which grows in the ntilles Islands, and is pretty much like the China plant. is used by sugar-bakers for refining the sugar.

ANJOU, a province and duchy of France before the evolution, bounded on the east by Touraine, on the south y Poitou, on the west by Bretagne, and on the north by Maine. It is now included under the Maine and Loire and the Sarthe and Mayenne. It is 70 miles in length, and in breadth 60. Through this province run five navi-gable rivers; the Loire, which divides it into two parts; the Vienne, the Toue, the Mayenne, and the Sarthe.

The air is temperate, and the country agreeably diver-sified with hills and meadows. There are 33 forests of oak-trees mixed with beech. The country produces white wine, wheat, barley, rye, oats, peas, beans, flax, hemp, walnuts, and some chesnuts. In Lower Anjou they make cider. There are fruit-trees of all kinds, and pasture proper for horses. The greatest riches of the province consist in cows, oxen, and sheep. There are several coal and iron mines, and yet there are but two forges in the whole province. There are quarries of marble and of slate, as well as quarries of white stone, proper for building, on the side of the river Loire. Here are also several salt-petre works, and some glass-houses. The principal towns, besides Angers the capital, are, Saumur, Brisac, Pont de Cé, La Fleche, and Beaufort.

ANKER, a liquid measure at Amsterdam. It contains about 32 gallons English measure.

ANKLAM, a circle in the government of Stettin and the Prussian province of Pomerania. It extends over 566 square miles, or 363,240 English acres. There are within it 4 cities, 6 towns, and 201 villages. The inhabitants are 30,856. The land is a plain, with extensive woods, and about twenty fresh-water lakes, the largest of which is the Ahlbeckr. The feeding of cattle and growing of corn are the chief objects of agriculture; besides which, some hops and tobacco, and much flax, are grown. The woods afford much profitable employment, and furnish charcoal to the iron-works in Pomerania. The capital of the circle is of the same name. It is situated on the river Peene, and is now without fortifications. It contains 3 churches, 3 hospitals, 599 houses, and 5833 inhabitants. By means of the river, which is navigable, it carries on some trade; and it has manufactures of cloth, hosiery, tobacco, snuff, and leather. It is in long. 24. 1. 59. E. lat. 53. 49. 15. N.

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[1] The following summary from the pen of Mr Brown contains the renewed expression of that gentleman's opinion, matured by me recent experiments on the subject of active molecules. "That extremely minute particles of solid matter, whether obtained om organic or inorganic substances, when suspended in pure water or in some other aqueous fluids, exhibit motions for which I am nable to account, and which, from their irregularity and seeming independence, resemble in a remarkable degree the less rapid mo-ons of some of the simplest animalcules of infusions. That the smallest moving particles observed, and which I have termed Ac-ve Molecules, appear to be spherical, or nearly so, and to be between $\frac{1}{25000}$th and $\frac{1}{30000}$th of an inch in diameter; and that other rticles of considerably greater and various size, and either of similar or of very different figure, also present analogous mo-ons in like circumstances. I have formerly stated my belief that these motions of the particles neither arose from currents in the uid containing them, nor depended on that intestine motion which may be supposed to accompany its evaporation. These causes motion, however, either singly or combined with others,—as the attractions and repulsions among the particles themselves, their nstable equilibrium in the fluid in which they are suspended, their hygrometrical or capillary action, and in some cases the disengage-ent of volatile matter, or of minute air-bubbles,—have been considered by several writers as sufficiently accounting for the appear-nces. Some of the alleged causes here stated, with others which I have considered it unnecessary to mention, are not likely to be verlooked, or to deceive observers of any experience in microscopical researches; and the insufficiency of those enumerated may, I ink, be satisfactorily shown by means of a very simple experiment. This experiment consists in reducing the drop of water con-ining the particles to microscopic minuteness, and prolonging its existence by immersing it in a transparent fluid of inferior specific ravity, with which it is not miscible, and in which evaporation is extremely slow. If to almond oil, which is a fluid having these roperties, a considerably smaller proportion of water, duly impregnated with particles, be added, and the two fluids shaken or tritu-ated together, drops of water of various sizes, from $\frac{1}{50}$th to $\frac{1}{2000}$th of an inch in diameter, will be immediately produced. Of these, e most minute necessarily contain but few particles, and some may be occasionally observed with one particle only. In this man-er minute drops, which, if exposed to the air, would be dissipated in less than a minute, may be retained for more than an hour. ut in all the drops thus formed and protected, the motion of the particles takes place with undiminished activity, while the rincipal causes assigned for that motion, namely, evaporation and their mutual attraction and repulsion, are either materially re-uced or absolutely null."

Ann || Anna.

ANN, or ANNAT, in *Scotish Law*, is half a year's stipend, which the act 1672, c. 13, gives to the executors of ministers of the church of Scotland, over and above what was due to the minister himself for his incumbency. As it is a mere gratuity given by the law to those whom, it is presumed, the deceased could not sufficiently provide for, so it is neither assignable by him during his life, nor attachable by his creditors after his death.

ANNA, ANA, or ANAH, a town of Arabian Irac, or pachalic of Bagdad, which extends five or six miles along the western bank of the Euphrates. It consists of a single street built on both sides. The houses are of stone, two stories high, and separated from each other, as in other eastern towns, by beautiful gardens, filled with fruit-trees, bearing lemons, oranges, citrons, quinces, figs, dates, pomegranates, and olives. It is an open and defenceless place; and in 1807 it was attacked by the Wahabees, who gave it up to plunder, and perpetrated the most horrible cruelties, massacring the greater part of the inhabitants, and setting the town on fire; after which they retreated with their plunder, carrying into captivity many women and children. The inhabitants are said, previous to this calamity, to have been more polished than those in the neighbourhood, and to have consisted chiefly of Arabians, who were, however, addicted to their usual vocation of robbery when any opportunity offered. Population about 3000. 260 miles east of Damascus; 220 south-east of Aleppo. Long. 41. 15. E. Lat. 34. N.

ANNA *Comnena*, daughter of the emperor Alexius Comnenus I., was not less distinguished by her elevated rank than by her mental qualifications. Her superiority of mind began early to display itself. Despising the effeminacy and voluptuousness of the court in which she was educated, she directed her attention to literary pursuits. Indulging her favourite studies, she solicited the acquaintance of the more eminent philosophers of that period.

But the pursuits of literature did not induce her entirely to abandon society; she gave her hand to Nicephorus Briennius, a young nobleman of a respectable family. This accomplished woman was, however, actuated with unjustifiable ambition; and, during the last illness of her father, she united with the empress Irene in attempting to prevail upon that monarch to disinherit his own son, and give the crown to her husband. The affection and virtue of the father prevailed over female address and intrigue. But the ambition of Comnena was not diminished; for she entered into a conspiracy to depose her brother; and when her husband displayed a timidity and hesitation in this unjust enterprise, she exclaimed that "nature had mistaken their sexes, for he ought to have been the woman."

Either through the vigilance of her brother, or the timidity of her husband, the treasonable plot was discovered, and Anna punished with the confiscation of all her property. But generosity has an opportunity of displaying its real nature when an enemy is vanquished; thus was the generosity of her brother displayed on the present occasion, by returning all her property. Ashamed, however, of her base conduct, she retired from court, and never more possessed any influence there. Disappointed ambition took shelter among the walks of literature, and she employed herself in her solitude in writing the history of her father's reign. This production of her pen is still extant, and composes a part of the celebrated collection of the *Byzantine Historians*. The stores of rhetoric are ransacked to embellish this work, and every effort made to enrich it with science; but the general complexion of it is rather like an apology than an impartial narrative. It must, however, be acknowledged that she is not more partial than many other Latin historians, and that her history contains many valuable facts and observations.

ANNABERG, a city on the mountains in the bailiwick of Wolkenstein, in the circle of Erzgebirg, in the kingdom of Saxony. It is 2820 feet above the level of the sea, in the midst of a mining district, which yields silver, tin, and cobalt. It contains 592 houses, and 4500 inhabitants, who are employed in manufacturing tapes, lace, sewing-silk, and many other articles. It is in latitude 50. 35. 8. N. The longitude is not exactly ascertained.

ANNACHNAN, a small island of Ireland, on the south-west coast of the county of Galway, 22 miles from Galway.

ANNAGH, an island about 5 miles in circumference, on the west coast of Ireland, between the isle of Achil and the mainland of the county of Mayo. Long. 9. 39. W. Lat. 53. 58. N. There is a small village of the same name in the county of Cork, 5 miles from Charleville.

ANNALS, in matters of literature, a species of history which relates events in the chronological order wherein they happened. They differ from perfect history in this, that annals are but a bare relation of what passes every year, as a journal is of what passes every day: whereas history relates not only the transactions themselves, but also the causes, motives, and springs of actions. Annals require nothing but brevity; history demands ornament. Cicero gives the following account of the origin of annals. To preserve the memory of events, the *Pontifex Maximus*, says he, wrote what passed each year, and exposed it on tables in his own house, where every one was at liberty to read: this they called *annales maximi*; and hence the writers who imitated this simple method of narrating facts were called *annalists*.

ANNAN, a royal borough and parish of Scotland, in the county of Dumfries, situated on the river of the same name, about two miles above its junction with the Solway Frith. An elegant new bridge of three arches has been built within these three years. It has a good harbour; the highest tides rise 21 feet; 23 vessels belonged to the port in 1818, registering 1025 tons; at present (1830) there are 39 vessels, registering 3054 tons. These vessels are chiefly employed in the coasting trade. A cotton spinning manufactory has been long established in the town, giving employment to between 80 and 100 persons of different ages. The salmon fishery, which in former years was so very productive, has fallen off very considerably. The town has recently been much improved by the addition of several new streets and public buildings: among the latter is a handsome new academy, built and endowed by the heritors and borough-council; it is conducted by a rector and two masters, and is in a very flourishing state. The town unites with Dumfries, Kirkcudbright, Sanquhar, and Lochmaben, in sending a representative to parliament. The environs are very inviting; and few places are more beautiful than the river and its finely wooded banks, for eight or ten miles above the town. There was formerly a castle, built by the Bruces after they became lords of Annandale. The population of the parish is 4500, of the town 3000. The latter is 16 miles from Dumfries, and 78 from Edinburgh.

The river Annan, on which the town stands, rises in the county of Peebles, and flowing through Dumfriesshire, falls into the Solway Frith after a course of 30 miles. It abounds with trout and salmon. The stewartry or district of Annandale, of which Lochmaben castle was the chief fortalice, is a fertile vale, 24 miles long and about 14 miles broad. From its vicinity to England, and the continual incursions and predatory wars of the borderers, the greater part of it was uncultivated and common; but since the beginning of the last century all these wastes and commons have been subdivided and brought into

ulture, and the country has assumed a new appearance, hich may be ascribed not only to the division of the com-ions, but likewise to the improvement made on the roads.

Annandale formed a part of the Roman province of Va-ntia; and Severus's wall ending at Bowness on the op-osite coast of the Solway, it abounds with Roman sta-ons and antiquities.

The Roman camps at Birrens in Middlebie, on the hill of irrenswark, and at Torwood Muir in Dryfesdale, are still early entire, and their form is preserved; and the traces nd remains of a military road are yet visible in different arts of the country. The ruins of the house or castle of uchincass, in the neighbourhood of Moffat, once the at of that potent baron Thomas Randolph, earl of Murray, lord of Annandale, and regent of Scotland dur-g the minority of David II., covers above an acre of ound, and even now conveys an idea of the plan and rength of the building. The ancient castle of Com-ngan, formerly belonging to the Murrays, earls of An-ndale, and now to the earl of Mansfield, is still in a tole-able state of preservation; but except this castle, and that Hoddam, most of the other old fortalices and towers are ow taken down or in ruins.

ANNAND, William, dean of Edinburgh, the son of William Annand, minister of Ayr, was born at Ayr in 633. Five years after, his father was obliged to quit cotland with his family, on account of their loyalty to e king, and adherence to the episcopal government stablished by law in that country. In 1651 young An-nd was admitted a scholar in University College, Ox-rd; and though he was put under the care of a pres-yterian tutor, yet he took all occasions to be present the sermons preached by the loyal divines in and ear Oxford. In 1656, being then bachelor of arts, e received holy orders from the hands of Dr Thomas ulwar, bishop of Ardfert or Kerry in Ireland, and was ppointed preacher at Weston on the Green, near Bices-r in Oxfordshire. After he had taken the degree of aster of arts, he was presented to the vicarage of eighton-Buzzard in Bedfordshire, where he distinguished imself by his edifying manner of preaching till 1662, hen he went into Scotland in quality of chaplain to hn earl of Middleton, the king's high commissioner to e church of that kingdom. In the latter end of the ear 1663 he was instituted to the Tolbooth Church at dinburgh, and from thence was removed, some years fter, to the Tron Church of that city. In April 1676 e was nominated by the king to the deanery of Edin-urgh; and in 1685 he commenced doctor of divinity in e university of St Andrews. He wrote, 1. *Fides Ca-olica*, or the Doctrine of the Catholic Church. Lond. 661–2, 4to. 2. Solutions of many proper and profitable uestions; printed with the *Fides Catholica*. 3. *Panem uotidianum*, or a short Discourse tending to prove e legality, decency, and expediency of set forms of rayers in the churches of Christ; with a particular De-nce of the Book of Common Prayer of the Church of ngland. Lond. 1661, 4to. 4. *Pater Noster*, or the ord's Prayer explained. Lond. 1670, 8vo. 5. *Myste-um Pietatis*, or the Mystery of Godliness. Lond. 1672, vo. 6. *Doxologia*, or Glory to the Father, the Church's Hymn, reduced to glorifying the Trinity. Lond. 1672, vo. 7. *Dualitas*, or a twofold subject displayed and pened, conducible to godliness and peace in order: irst, *Lex Loquens*, the honour and dignity of magistracy; econdly, *Duorum Unitas*, or the agreement of magis-acy and ministry. Edinb. 1674, 4to. Dr Annand died n the 13th of June 1689, and was interred in the Grey-iars Church, Edinburgh.

ANNAPOLIS, the chief town in Maryland, in North America. It stands upon a sort of peninsula on the west side of the Chesapeak, and is a small town, but well built. It contained 2260 inhabitants in 1820.

Anne || St Anne's Day.

ANNE, queen of Great Britain, second daughter of King James II. by his first wife, Anne Hyde, was born in 1664. In 1683 she married George prince of Denmark, by whom she had several children, but none of them arrived at the age of maturity. On the death of King William she ascended the throne, A. D. 1702, and her reign comprehends one of the most illustrious periods of English history. Possessed, however, of a very feeble character, which did not permit her to act for herself, this period is the reign of her counsellors and favourites; and she exhibited no decided inclination which could influence state affairs, except a strong passion for tory principles, both in church and state. She died in August 1714, of a dropsy, in the 50th year of her age and 13th of her reign.

ANNE Boleyn, queen of Henry VIII. king of England, daughter of Sir Thomas Boleyn, a nobleman of a powerful family and numerous alliances. The daughter of the duke of Norfolk was her mother, and during the reign of the former king her father had been honoured with several embassies. Mary, the king's sister, who married Louis XII. king of France, carried over this lady with her at an early age, where she imbibed the freedom, the vivacity, and the openness of manners of that nation. After the death of Louis, that queen returned to England, and Anne continued to attend her royal mistress. Having some time after left her service, she was introduced into the family of the duchess of Alençon. In addition to all her acquired accomplishments, she possessed the greatest personal elegance, and was highly famed in that age.

History does not explicitly mention whether or not it was on her account, but upon her return to England the king expressed his scruples concerning his union with Catharine of Arragon. Enamoured, however, of Anne, he expressed his attachment to her; but she was possessed of too much virtue and policy to confer any improper favours. This prudent and virtuous restraint only increased the passion of Henry; and placing her at court, he distinguished her by many marks of royal favour. The impetuous king at length came to the resolution to divorce his queen, to make way for his favourite Anne. In this instance the injury done to that queen proved the cause of the final separation of England from the dominion of the pope. Various delays and difficulties occurring to the divorce, Henry privately married Anne during the month of November 1532; and in April following he publicly declared her queen of England. The famous Queen Elizabeth was the first-fruits of this marriage, who was born in September following. For some time Anne enjoyed a considerable share of the royal favour, and she made use of that influence in subduing the haughty prelate Wolsey, and widening the breach between the king and the pope. But this favour was not of long continuance; for the king, ever varying in his temper, allowed jealousy to enter his bosom, which her thoughtless demeanour tended in some measure to excuse. She was accused of adultery with several of the household officers, and even with her own brother Lord Rochford; and having been tried on a charge of high treason, was condemned on very scanty proof to be beheaded; which sentence was executed in May 1536. She to the last resolutely denied any serious guilt.

St Anne's Day, a festival of the Christian church, celebrated by the Latins on the 26th of July, but by the Greeks on the 9th of December. It is kept in honour of Anne or Anna, mother of the Virgin Mary.

Annealing. Glass.

ANNEALING, by the workmen called *nealing*, is a process used in glass-making, and in the manufacture of certain metals. In glass-making it consists in placing the bottles, &c. whilst hot, in a kind of oven or furnace, where they are suffered to cool gradually. They would otherwise be too brittle for use. The difference between unannealed and annealed glass, with respect to brittleness, is very remarkable. When an unannealed glass vessel is broken, it often flies into a small powder, with a violence seemingly very unproportioned to the stroke it has received. In general it is in greater danger of breaking from a very slight stroke than from one of some considerable force. One of these vessels will often resist the effects of a pistol bullet dropt into it from the height of two or three feet; yet a grain of sand falling into it will make it burst into small fragments. This takes place sometimes immediately on dropping the sand into it; but often the vessel will stand for several minutes after, seemingly secure; and then, without any new injury, it will fly to pieces. If the vessel be very thin, it does not break in this manner, but seems to possess all the properties of annealed glass.

The same phenomena are still more strikingly seen in glass drops or tears. They are globular at one end, and taper to a small tail at the other. They are the drops which fall from the melted mass of glass on the rods on which the bottles are made. They drop into the tubs of water which are used in the work; the greater part of them burst immediately in the water. When those that remain entire are examined, they discover all the properties of unannealed glass in the highest degree. They will bear a smart stroke on the thick end without breaking; but if the small tail be broken, they burst into small powder with a loud explosion. They appear to burst with more violence, and the powder is smaller, in an exhausted receiver, than in the open air. When they are annealed they lose these properties.

Glass is one of those bodies which increase in bulk when passing from a fluid to a solid state. When it is allowed to crystallize regularly, the particles are so arranged that it has a fibrous texture. It is elastic, and susceptible of long-continued vibrations; but when a mass of melted glass is suddenly exposed to the cold, the surface crystallizes, and forms a solid shell round the interior fluid parts. This prevents them from expanding when they become solid. They therefore have not the opportunity of a regular crystallization, but are compressed together with little mutual cohesion. On the contrary, they press outward to occupy more space, but are prevented by the external crust. In consequence of the effort of expansion in the internal parts, the greater number of glass drops burst in cooling; and those which remain entire are not regularly crystallized. A smart stroke upon them communicates a vibration to the whole mass, which is nearly synchronous in every part; and therefore the effort of expansion has little more effect than if the body were at rest; but the small tail and the surface only are regularly crystallized. If the tail be broken, this communicates a vibration along the crystallized surface, without reaching the internal parts. By this they are allowed some expansion; and overcoming the cohesion of the thin outer shell, they burst it, and are dispersed in powder.

In an unannealed glass vessel the same thing takes place. Sometimes the vibration may continue for a considerable time before the internal parts overcome the resistance. If the vessel be very thin, the regular crystallization extends through the whole thickness; or at least the quantity of compressed matter in the middle is so inconsiderable as to be incapable of bursting the external plate.

By the process of annealing the glass is kept for some time in a state approaching to fluidity; the heat increases the bulk of the crystallized part, and renders it so soft, that the internal parts have the opportunity of expanding and forming a regular crystallization.

In the manufactures in which the malleable metals are employed, annealing is used to soften a metal after it has been rendered hard by the hammer; and also to soften cast-iron, which is rendered very hard and brittle by rapid cooling.

In the manufacture of steel goods, which are first formed by the hammer, and require to be filed or otherwise treated, and in which softness and flexibility are essential to the change, annealing is absolutely necessary. This is particularly the case in making files and scissors, that the metal may be left sufficiently soft for cutting the teeth, and for filing off those parts which cannot be ground. Annealing is not less necessary in the drawing of wire, whether iron, copper, brass, silver, or gold. The operation of drawing soon gives the wire a degree of hardness and elasticity which, if not removed from time to time by annealing, would prevent the extension of the wire, and render it extremely brittle. The same operation is also necessary in rolling or flatting those metals which are in a cold state, such as brass, silver, gold, &c. The brazier who forms vessels of copper and brass by the hammer, can work upon it only for a little time before he is obliged to anneal it.

The common methods employed for annealing iron and steel are very injudicious, and materially injure the latter when it is used for making cutting instruments. After they have been formed by the hammer, they are generally piled up in an *open* fire, slowly raised to red heat, and then allowed as gradually to cool. By this method the surface of the steel will be found considerably scaled, from the action of the oxygen of the atmosphere. When it is remembered that steel consists of iron joined to carbon, it will be evident that the steel immediately under the scaly oxide will be deprived of its carbon, which has been carried off by the attraction of the oxygen; and, in consequence, will lose the property of acquiring that degree of hardness necessary to a cutting instrument.

Nothing, therefore, can be more obvious, than that steel particularly should be annealed in close vessels, to prevent that effect. For this purpose the goods should be placed in a trough or recess made of fire-stone or fire-brick, and stratified with ashes or clean sand, and finally covered with a thick stratum of the same; but if the size of the vessel be small, it may have a cover of its own materials. This oven or trough must now be heated by the flame of a furnace passing under and round it, till the whole is of a red heat. It must then be suffered to cool, without letting in the air. The goods so treated will be much softer than by the common method. The surface, instead of becoming scaled, will have acquired a metallic whiteness, from the presence of a small quantity of carbonaceous matter contained in the ashes in which they were imbedded. They will become so flexible also, as to allow them to bend considerably without breaking, which is very far from being the case before the operation. The fracture, before annealing, will be smooth and short; but afterwards it will be rough, exhibiting bright parts, of a crystalline appearance. Wire, especially that of iron and steel, should be treated in a similar way when it is annealed. The wire used for some purposes requires to be soft, and is sold in that state. If the wire, after finishing, when it is bright and clean, were to be annealed in contact with oxygen, it would not only lose all its lustre and smoothness, but much of its tenacity. The process above mentioned will therefore be particularly necessary in annealing finished wire, as well as in softening it from time to time during the drawing.

Copper and brass suffer much less than iron and steel om annealing in the open air, and do not require to be eated above a low red heat. If, however, the lustre is to e preserved, a close vessel would be desirable. The lat- er metals, after annealing, although much discoloured y the oxygen of the atmosphere, may be cleansed by nmersion in a hot liquor composed of water and a small uantity of sulphuric or nitric acid. Very small brass or opper wire is frequently annealed by exposing it to the ame of hay or straw. In casting minute pieces of pig- on, which is generally done in wet sand, the metal pos- esses the property of steel to such a degree as to assume, y the rapid cooling, a degree of hardness equal to hard- ned steel; at the same time that the articles are so brittle s to break by falling on the ground. When, however, hese goods are treated in the way above directed, they equire a degree of softness which renders them pene- rable by the file, and at the same time capable of bend- ng. In this state they are much less tenacious than steel, ut still so much so as to have been sold in the form of utlery for steel.

The change which metals undergo by annealing is not et thoroughly understood. Most of the malleable metals re susceptible of two distinct forms, one called the crys- alline form, which they assume by slow cooling; and the ther the fibrous, which is acquired by hammering or roll- ng. When this, however, is carried beyond a certain oint, the metal becomes so hard that it is not capable of eing bent far without breaking. All the malleable me- als in the ingot or in their cast state are brittle, and ex- ibit a crystalline fracture. By hammering or rolling hey become more tenacious, and break with difficulty, xhibiting what is called a fibrous fracture. At the same me they become stiffer and more elastic. They lose the tter properties by annealing, but become more malleable. f the annealing, however, be long continued, the mal- eability diminishes, and they again have a crystalline racture. Zinc by wire-drawing becomes very flexible, nd possesses a degree of tenacity not inferior to that of opper; but, if it be kept in boiling water for a length of me, it will resume its original brittleness, and show a rystalline appearance when broken. This proves that he particles of metals can change their arrangement ithout losing their solid form; which is still more strong- y confirmed by the fact, that brass wire loses its tenacity y exposure to the fumes of acids, and even by the pre- ence of a damp atmosphere. This is not caused by the oisture, but by the action of air upon the moistened sur- ace. The manufacturers of common pins are obliged to eep their wire in a dry atmosphere, or immersed in vater. If the wire be first moistened, and then exposed o the air, it will assume the brittle state much sooner. n this condition it breaks with a crystalline fracture, si- nilar to that exhibited by an ingot. When a steel plate, uch as a watch-spring, has been once tempered, the ope- ation of simply rubbing it bright will render it soft and lastic. The same change is brought about by slightly hammering it. It, however, resumes its elastic state by being carefully heated till it becomes of a blue colour. f the heat be continued to redness, particularly in a close essel, it becomes perfectly annealed.

ANNECY, a city in the kingdom of Sardinia, the capi- al of the province of Genevois, in the duchy of Savoy. It is t the foot of the mountain Semina, on the banks of the ake of that name. It is the most industrious place in Savoy, having manufactures of cotton goods, of hats, glass, nd earthenware, and several distilleries and tanneries, nd near it some iron-works. It contains a cathedral, a hurch, five monasteries, and the same number of nun- neries. The relics of St Francis de Sales, preserved in St Mary's Church, draw a vast number of pilgrims annu- ally to the city. The population in 1816 amounted to 5467 persons. It is in long. 5. 9. E. and lat. 45. 53. N.

Annesley || Annobon.

ANNESLEY, Arthur, earl of Anglesea, and lord privy seal in the reign of King Charles II., was the son of Sir Francis Annesley, baronet, Lord Mount-Norris, and Viscount Valentia, in Ireland, and was born at Dublin on the 10th of July 1614. He was for some time at the uni- versity of Oxford, and afterwards studied the law at Lin- coln's Inn. He had a considerable share in public trans- actions, for in the beginning of the civil war he sat in the parliament held at Oxford; but afterwards became recon- ciled to the opposite party, and was sent commissioner to Ulster, to oppose the designs of the rebel Owen Roe O'Neal. He engaged in several other affairs with great success. He was president of the council of state after the death of Oliver, and was principally concerned in bringing about the Restoration, soon after which King Charles II. raised him to the dignity of a baron, by the title of Lord Annesley of Newport-Pagnel, Bucks; and a short time after he was made earl of Anglesea. Du- ring that reign he was employed in some very important affairs, was made treasurer of the navy, and for some time held the office of lord privy seal. He was a person of great abilities, of very extensive learning, and was well ac- quainted with the constitution and laws of England. He died in April 1686, in the 73d year of his age. In his lifetime he published the following pieces:—1. Truth un- veiled, in behalf of the Church of England; being a Vin- dication of Mr John Standish's Sermon, preached be- fore the king, and published by his Majesty's command. 1676, 4to. To which is added, A short Treatise on the subject of Transubstantiation. 2. A Letter from a Person of Honour in the Country, written to the Earl of Castle- haven; being observations and reflections on his Lord- ship's Memoirs concerning the Wars of Ireland. 1681, 8vo. 3. A true Account of the whole Proceedings between James Duke of Ormond and Arthur Earl of Anglesea, before the king and his council, &c. 1682, folio. 4. A Letter of Re- marks upon Jovian. 1683, 4to. Besides these, he wrote several other works, some of which were published after his decease; as, 5. The Privileges of the House of Lords and Commons, argued and stated in two conferences be- tween both Houses, April 19 and 22, 1671: To which is added, A Discourse, wherein the Rights of the House of Lords are truly asserted; with remarks on the seeming arguments and pretended precedents offered at that time against their lordships. 6. The King's Right of Indulgence in Spiritual Matters, with the Equity thereof, asserted. 1688, 4to. 7. Memoirs, intermixt with moral, political, and historical observations, by way of discourse, in a let- ter to Sir Peter Pett. 1693, 8vo.

ANNIVERSARY, the annual return of any remarkable day. Anniversary days, in old times, more particularly denoted those days in which an office was yearly perform- ed for the souls of the deceased, or the martyrdom of the saints was yearly celebrated in the church.

ANNOBON, a small island in Africa, on the east coast of Loango, belonging to the Portuguese. It lies in long. 5. 30. E. lat. 1. 32. S., and receives its name from being discovered on the new year's day. According to Pyrard, it is about five or six French leagues in circuit; Braud- raud makes it ten leagues. It contains two high moun- tains, having their tops continually enveloped in clouds, and thus occasioning frequent rains. Off the south-east of the island are two rocks, one of which is low, and upon a level with the surface of the sea; the other higher and larger, but both dangerous to shipping in the night: between them the channel is deep and clear. On the same side of the island is a convenient watering place; but the road

Annobon || Annuities.

to the north-west side is difficult and dangerous, though the one most frequented by ships that have no intention of touching upon the continent. In either place it is difficult to take in a sufficient quantity of water, on account of the violent surf. The best road for ships lies on the north-east side, where they may anchor in 7, 10, 13, or 16 fathoms, on a fine sand, opposite to the Negro village. The climate is wholesome, and the air clear and serene for the greater part of the year. The island contains a number of fertile valleys, which produce Turkey corn, rice, millets, yams, potatoes, and afford pasture for abundance of cattle and sheep. Poultry and fish also abound; but the only mercantile production is cotton, in small quantity, but esteemed equal in quality to any produced in India.

In the year 1605 the Dutch admiral Matelief found 200 negroes and two Portuguese on Annobon, most of them able to bear arms. The inhabitants are subject to the Portuguese governor, who is the chief person in the island; at the same time the negroes have their own chief, subordinate to him. They are all rigid catholics, having been either compelled or persuaded by the Portuguese to embrace that religion; and, like all other converts, they are bigoted in proportion to their ignorance.

ANNONA, in *Roman Antiquity*, denotes provision for a year of all sorts, as of flesh, wine, &c. but especially of corn. Annona is likewise the allowance of oil, salt, bread, flesh, corn, wine, hay, and straw, which was annually provided by the contractors for the maintenance of an army.

ANNONÆ PRÆFECTUS, in *Antiquity*, an extraordinary magistrate, whose business it was to prevent a scarcity of provisions, and to regulate the weight and fineness of bread.

ANNONAY, a small town of France, in the department of Ardeche, formerly Upper Vivarais, seated on the river Deume. Long. 4. 52. E. Lat. 45. 15. N.

ANNOT, a small city on the mountains of Provence in France. Long. 7. 0. E. Lat. 44. 4. N.

ANNOVER, a Spanish town not far from the Tagus, in the province of Toledo, containing 400 houses, 2000 inhabitants, and a saltpetre manufactory.

ANNUALRENT, in *Scotish Law*, denotes the yearly interest or profit due by a debtor in a sum of money to a creditor for the use of it.—A *Right of* ANNUALRENT was the original method in Scotland of burdening lands with a yearly payment for the loan of money, before the taking of interest was allowed.

ANNUITIES.[1]

THE doctrine of Compound Interest and Annuities-certain is too simple ever to have occupied much of the attention of mathematicians: inquiries into the values of interests dependent upon the continuance or the failure of human life, being more interesting and difficult, have occupied them more, but yet not so much as their importance would seem to demand; the discoveries both in Pure Mathematics and Physics, especially those of Newton, which distinguished the close of the seventeenth century, having provided them with ample employment of a more interesting kind, ever since the subjects of this article were submitted to calculation.

Fermat, Pascal, and Huygens, by laying the foundation of the doctrine of probabilities, about the middle of that century, first opened the way to the solution of problems of this kind. The earliest mathematical publication on probabilities, the little tract of Huygens, *De Ratiociniis in Ludo Aleæ*, appeared in 1658; and in 1671 his celebrated countryman John de Witt published a treatise on Life-Annuities in Dutch. (Montucla, *Hist. des Math.* tome iii. p. 407.) This, however, appears to have been very little known or read, and to have had no sensible influence on the subsequent progress of the science, the origin of which may be properly dated from the publication of Dr Halley's paper on the subject, in the *Philosophical Transactions* for the year 1693 (No. 196). That celebrated mathematician there first gave a table of mortality, which he had constructed from observations made at Breslaw, and showed how the probabilities of life and death, and the values of annuities and assurances on lives, might be determined by such tables; which, he informs us, had till then been only done by an imaginary valuation. Besides his algebraical reasonings, he illustrated the subject by the properties of parallelograms and parallelopipedons: there are, perhaps, no other mathematical inquiries, in the prosecution of which algebra is entitled to so decided a preference to the elementary geometry as in these, and this example of the application of geometry has not been followed by any of the succeeding writers.

In the year 1724 M. de Moivre published the first edition of his tract entitled *Annuities on Lives*. In order to shorten the calculation of the values of such annuities, he assumed the annual decrements of life to be equal; that is, that out of a given number of persons living at any age, an equal number die every year until they are all extinct; and upon that hypothesis he gave a general theorem, by which the values of annuities on single lives might be easily determined. This approximation, when the utmost limit of life was supposed to be 86 years, agreed very well with the true values between 30 and 70 years of age, as deduced from Dr Halley's table; and the method was of great use at the time, as no tables of the true values of

[1] Hardly any terms are made use of in this article which may properly be considered technical. But since it is desirable that the reader should have perfectly clear and well-defined ideas of the terms that are employed, in the demonstrative part, which follows the historical, a few have been defined in the paragraphs where they are first introduced; and we here give those terms in alphabetical order, with the numbers of the paragraphs in which their definitions are given:—

Term.	*Paragraph.*
Annuity	3
Annuity, Certain	4
Annuity, Deferred	20
Annuity, Life	31
Annuity, Temporary Life	58
Annuity on any Life or Lives	62
Assurance on any Life or Lives	77
Mortality, Table of	32
Years' Purchase, No. of, that an Annuity is worth	6

annuities had then been calculated, except a very contracted one inserted by Dr Halley in the paper mentioned above. But, upon the whole, this hypothesis of De Moivre has probably contributed to retard the progress of the science, by turning the attention of mathematicians from the investigation of the true law of mortality, and the best methods of constructing tables of the real values of annuities.

The same distinguished analyst also endeavoured to approximate the values of joint lives; but it has since been found that the formulæ he gave for that purpose are too incorrect for use. Mr Thomas Simpson published his *Doctrine of Annuities and Reversions* in the year 1742, in which the subject is treated in a manner much more general and perspicuous than it had been previously. His formulæ are adapted to any table of mortality; and, in the seventh corollary to his first problem, he gave the theorem demonstrated in the 149th number of this article, to which we owe all the best tables of the values of life-annuities that have since been published.

In the same work he also gave a table of mortality deduced from the London observations, and four others calculated from it, of the values of annuities on lives, each at three rates of interest; the first for single lives, the three others for two and three equal joint lives, and for the longest of two or of three lives.

These were the first tables of the values of joint lives that had been calculated; for although Dr Halley had shown, half a century before, how such tables might be computed, and had taken considerable pains to facilitate the work, the necessary calculations by the methods known previous to the publication of Mr Simpson's treatise were so very laborious that no one had had the courage to undertake them. And unfortunately the mortality according to the London table was so much above the common average, that the values of annuities in Mr Simpson's tables were much too small for general use.

In the year 1746 M. Deparcieux published his *Essai sur les Probabilités de la Durée de la Vie Humaine*, in which he gave several valuable tables of mortality deduced from the mortuary registers of different religious houses, and from the lists of the nominees in the French tontines; and a table of the values of annuities on single lives, at three rates of interest, calculated from his table of mortality for the tontine annuitants. These tables were a great acquisition to the science, as, before their publication, there were only two extant that gave tolerably exact representations of the true law of mortality—Dr Halley's for Breslaw, and one constructed but a short time before by M. Kersseboom, principally from registers of Dutch annuitants. Those of M. Deparcieux for the monks and nuns were the first ever constructed for the two sexes separately; and by them the greater longevity of females was made evident.

The work commences with an algebraical theory of annuities-certain; but the principal essay, *On the Probability of the Duration of Human Life*, is perfectly intelligible to those who have not studied mathematics. It is written with great judgment and perspicuity, but contains very little more than the explanation of the construction of his tables, some of which relate to tontines; and he did not avail himself to the extent he might have done, of the excellent tract of Thomas Simpson.

This work, however, appears to have been more read upon the Continent, and to have contributed more to the diffusion of this kind of information there, than all the other writings on the subject. The article *Rentes Viagères* in the French *Encyclopédie* is acknowledged to have been taken entirely from it, as was also the article VIE, *durée de la*; and these are proofs, among many others that might be produced, how little M. d'Alembert and the principal mathematicians his contemporaries attended to the subject.

In the year 1752 Mr Simpson published, in his *Select Exercises*, a supplement to his doctrine of Annuities; wherein he gave new tables of the values of annuities on two joint lives, and on the survivor of two lives, much more copious than those he had inserted in the principal work; but these also were calculated from his London table of mortality.

The celebrated Euler, in a paper inserted in the *Memoirs of the Royal Academy of Sciences at Berlin* for the year 1760, gave a formula by which the value of an annuity on a single life of any age may be derived from that of an annuity on a life one year older; which formula was included in that given by Mr Simpson 18 years before for effecting the same purpose in the case of any number of joint lives; and by this compendious method M. Euler calculated a table of the values of single lives from M. Kersseboom's table of mortality.

The first edition of Dr Price's *Observations on Reversionary Payments* was published in 1770, and its chief object was, to give information to persons desirous of forming themselves into societies for the purpose of making provision for themselves in old age, or for their widows. When tables of the values of single lives, and of two joint lives, are given, the methods of determining the terms on which such provisions can be made with safety to all the parties concerned are very simple, and were at that time well understood in theory by the mathematicians who had studied the subject; but, for want of the requisite tables, the algebraical formulæ had till then been of little practical utility.

In the prosecution of this laudable design, Dr Price was obliged to have recourse to approximations. He informs us, that by following M. de Moivre too implicitly in his rules for determining the value of two joint lives, he was led into difficulties which convinced him that they were not only useless but dangerous: he therefore calculated a table of these values upon M. de Moivre's hypothesis of the decrements of life being equal, and its utmost limit 86 years, from a correct formula given by Mr Simpson in his doctrine of Annuities (Cor. 5, Prob. 1). By this, and a table of the values of single lives, calculated by Mr Dodson on M. de Moivre's hypothesis, he was enabled to give answers tolerably near the truth, to some of the most interesting questions of this kind, and to show that the plans of several of the societies then recently established, were quite inadequate; and instead of the benefits they promised, could only, in the end, produce disappointment and distress, unless they either dissolved or reformed themselves.

The work also contained instructive dissertations on the probabilities and expectations of life, and on the mean duration of marriage and of widowhood; besides accounts of some of the principal societies which had then been formed for the benefit of old age and of widows, with observations on the method of forming tables of mortality for towns, and two new tables of that kind constructed from registers kept at Norwich and Northampton. Mr Morgan's *Doctrine of Annuities and Assurances* was published in 1779, containing tables of the values of single lives, of two equal joint lives, and of two lives differing in age by 60 years, calculated from the Northampton table of mortality. And in the same year M. de Saint-Cyran published his *Calcul des Rentes Viagères sur Une et sur Plusieurs Têtes*, wherein the valuation of annuities on lives is treated algebraically, but in a manner much inferior in all respects to that of Mr Simpson; and six tables are given of the values of annuities—on single lives, on the survivor of two lives, and on the last survivor of three, calculated

History. from M. Kersseboom's table of mortality. Although the values in the cases of two and of three lives were only determined by approximation, these tables were, just then, a valuable acquisition to the science; but their use was entirely superseded only four years after, by the publication of others much more valuable.

The fourth edition of Dr Price's *Observations on Reversionary Payments* appeared in 1783. One of the best effects of the preceding editions on the progress of the science had been, to direct the public attention to these inquiries, by showing their important uses in the affairs of life; and to procure the requisite *data* for forming tables of mortality, that should illustrate the laws according to which human life wastes under different circumstances, by exciting the curiosity of intelligent men who had the necessary leisure and means of information. The ingenious author had accordingly been furnished with the necessary abstracts of mortuary registers which had been kept with these views, by Dr Haygarth at Chester, Dr Aikin at Warrington, and the Rev. Mr Gorsuch at Holy-Cross, near Shrewsbury, since the publication of the first edition; also by Mr Wargentin, with the mean numbers both of the living and the annual deaths in all Sweden and Finland for 21 successive years; in all of which the sexes were distinguished; and from these *data* he constructed tables of mortality that threw great light on the subject. He also inserted in this edition an improved table of mortality for Northampton; and, what had been so long wanted, a complete set of tables of the values of annuities on single lives at six rates of interest, and on two joint lives at four, all calculated from the new Northampton table. The combinations of joint lives were sufficiently numerous to admit of all the values not included being easily interpolated. Besides these, he also gave tables of the values of annuities on single lives from the Swedish observations, both with and without distinction of the sexes, and on two joint lives without that distinction.

The values given in these tables are too low for the general average of lives at all ages under 60; but in the treatise of Mr Baron Maseres on the *Principles of the Doctrine of Life Annuities*, which was published in the same year (1783), others were given, calculated from the table of mortality which M. Deparcieux constructed from the lists of the nominees in the French tontines. The tables for single lives are calculated at twelve different rates of interest from 2 to 10 *per cent.*, but those for joint lives only at $3\frac{1}{2}$ and $4\frac{1}{2}$ *per cent.*; and the combinations they include are only those of ages that are equal, or that differ by 5 or 10 years, and the multiples of 10.

There is reason to believe that the values in these tables, at all ages under 75 or 80 years, are nearer the truth, for the average of this country, than any others then extant; but certainly for the average of lives on which annuities and reversions depend. After that period of life, however, they are too small; and, in most cases, it is difficult to derive the values of joint lives from them with sufficient accuracy, on account of the contracted scale they have been calculated upon.

It was not Dr Price's object to deliver the elements of the science systematically; but he treated most parts of it with great judgment, enriched it with a vast collection of valuable facts and observations, and corrected several errors into which some of the most eminent writers upon it had fallen. The mathematical demonstrations (which are given in the notes) are much inferior to the rest of the work.

The values of reversionary sums and annuities, which depend upon some of the lives involved failing according to assigned orders of precedency, had been approximated by Mr Simpson in his *Select Exercises*, and by Mr Morgan in his *Doctrine of Annuities*; but the latter gentleman first gave accurate solutions of problems of this kind, in the *Philosophical Transactions* for the years 1788, 1789, 1791, 1794, and 1799.

Mr Baily's *Doctrine of Life Annuities and Assurances* was published in 1810. In it the whole subject is treated, except the construction of tables of mortality, on which the practical application of all the rest depends. In consequence of the author having adopted Mr Simpson's notation, this work presented a more perspicuous exposition of the whole theory, especially of the improvements made in it between the time when Mr Simpson wrote and the date of its publication, than had previously appeared. And in an appendix to it, published in 1813, principally for the purpose of explaining the construction and uses of tables for determining the values of life-annuities, calculated at a vast sacrifice of time and labour by Mr George Barrett, since deceased, formulæ were given for calculating from tables of that kind the values of temporary and deferred life-annuities and assurances, and also for determining the values of annuities and assurances when the annuity or the sum assured, instead of remaining always the same, increases or decreases from year to year by equal differences, with considerably greater facility and expedition than the same things could have been effected with by the tables and methods of calculation in previous use.

Except by these improvements, and the solution of the problems above stated to have been first given by Mr Morgan, which were severely criticised and given anew, with some amendments besides the important one of the notation in Mr Baily's work, the science had not been materially advanced, during a period of more than 30 years, which had elapsed since the appearance of the fourth edition of Dr Price's observations, when Mr Milne published his *Treatise on the Valuation of Annuities and Assurances on Lives and Survivorships*, in the year 1815.

The work consists of two volumes; the first is mathematical, the second entirely popular, except the notes and a few of the tables. The algebraical part of this article is merely a short abstract of the first volume, and may serve as a specimen of the manner in which the subject has been treated there; but the construction of tables of mortality, which forms the subject of the third chapter, has not been noticed here; neither is the valuation of reversionary sums or annuities depending upon assigned orders of survivorship treated in the present article; and these are parts of the work which will not be found the least interesting to mathematicians.

The second volume contains upwards of 50 new tables, with a few others that had been published before, but have been reprinted either on account of their value or scarcity, or both. Four of the new ones are tables of mortality constructed by the author, from registers kept at Carlisle and Montpellier, and in all Sweden and Finland, since the period of the observations Dr Price made use of: the sexes are distinguished in the tables for Sweden and Montpellier, but not in that for Carlisle. This last is the only table, besides those for Sweden and Finland, applicable to the mass of the people, that has been formed from the necessary *data*,—enumerations of the living, as well as registers of the deaths, in every interval of age.

Twenty-one of these tables, being the seventeenth to the thirty-seventh inclusive, in the collection at the end of the work, render it easy to apply the algebraical formulæ to practical purposes, and numerous examples of such applications are given. They have all been calculated from the Carlisle table of mortality; those of the values of life-annuities on the same extensive scale with those

nich Dr Price derived from the Northampton table. It i the author's opinion that the values of interests dependent upon the continuance or the failure of life may l derived from them more correctly than from any others ten extant, and he has taken considerable pains to assist ls readers in judging of this for themselves.

Besides the tables, the principal contents of the second vlume are explanations of their construction and uses. Lany of them relate to the progress of population,—the cmparative mortality of diffcrent diseases, of different sasons,—and of the two sexes at every age, the proportn of the sexes at birth, and that of the born alive to te still-born of each sex.

It will be found that the author has collected records c facts and observations of great value, and that he has cdeavoured to present the information they afford in te forms best calculated for the further prosecution of tese inquiries.

Mr Gompertz's *Sketch of an Analysis and Notation applcable to the estimation of the value of Life Contingencies* vs read at a meeting of the Royal Society on the 29th c June 1820, and printed in the Society's Transactions for tt year.

The second edition of Mr Morgan's *Principles and Doctne of Assurances and Annuities on Lives* was published i 1821. The formulæ for determining the values of cntingent reversions, first given by the author in the *Philosophical Transactions*, as above stated, were in this scond edition substituted for the approximations given in te first; and it contains tables of the values of annuities c single and joint lives, calculated from the Northamptn and Sweden tables of mortality, and taken from Dr Price's *Observations on Reversionary Payments*.

This cdition contains nothing new, except a table on te two last pages, showing the number of persons whose les were insured in the Equitable Society, who died of ch disease in each decade of age from 10 years to 80, d above 80 years of age, during a term of 20 years mmencing with 1801. Also (in the last line of the ble) " the number assured during the same term" in ch of these intervals of age. The obvious meaning of ts expression would seem to be, *the number of persons whose lives assurances were effected by the Society during se 20 years, in each interval of age.* This is the sense i which Mr Babbage understood it, and therefore drew ong inferences from it (in his *Comparative View of Life surance Institutions*, p. 63 and table 13). The late Dr ung was also misled by it, and appears to have taken se for the mean numbers of the lives on which the sote had policies in force in the several intervals of age ring these 20 years; and thence concluded that during se 20 years, according to that table, the mean number lives of all ages on which the society had policies in ce was more than 150,000, and that only one out of 00 of them died annually. (*Philosophical Transactions*, 26, p. 287.)

Indeed Mr Morgan himself, on the page preceding his ble, stated that it contained an account of all the deaths ich had happened in the society during 20 years, 'mong a population exceeding 150,000 persons."

If the numbers only in that last linc of the table had en given, without any explanation of them, it would, on due consideration, have been conjectured that they uld be no others than the sums of the numbers of lives ured by the society which were found to be in those ervals of age at one and the same period in each of se 20 years; that is, 20 times the mean numbers of them in the several intervals during the same term. But neither of Mr Morgan's explanations of them would admit of that construction.[1]

The present article was first published in the Supplement to this Encyclopædia in 1816.

In the article on the Law of Mortality in that Supplement, which appeared in 1822, it was shown that, according to Mr Morgan's statement, made at a general court of the Equitable Society in the year 1800, of the mortality which had taken place among the lives insured by that society as compared with the Northampton table, the mortality among those lives in each decade of age from 10 years to 50 was very nearly the same as in the Carlisle table of mortality; also that, above 50 years of age, the difference, upon the average, was not great. And early in 1826 were published *Tables of Life Contingencies*, by Mr Davies, and *A Comparative View of the various Institutions for the Assurance of Lives*, by Mr Babbage; in each of which works was given a table of the mortality which had prevailed among the lives insured in the Equitable Society at all ages above 10 years, constructed from that statement of Mr Morgan.

Mr Babbage gave also a table of the values of annuities on single lives of all ages above ten years, derived from his table of mortality above mentioned; and the indefatigable Mr Davies gave tables of the values of annuities on single and joint lives, calculated both from his table of mortality above mentioned and from the Northampton table, rather fuller and more complete than any that had previously been published, except that those derived from the law of mortality in the Equitable Society necessarily included no ages under 10 years. The values according to the Northampton table were given only at the rates of 3 and 4 per cent. interest; but Mr Davies, not content to take them on Dr Price's authority, has, like Mr Barrett, calculated them anew, and, as well as the other values of annuities, has carried them to four places of decimals. This author's comprehensive little book also contains many other tables of the values of annuities and assurances on lives and survivorships, with one of the values of policies of assurance, calculated from the Northampton table of mortality at 3 per cent. interest, which, as well as many another single table contained in it, must have cost him much time and labour; and those derived from the Northampton table of mortality must be very valuable to such of the assurance companies as take that table for their guide in transacting business.

Mr Babbage and Mr Davies also gave formulæ and tables similar to, or not materially different from, those of Mr Barrett above mentioned, for determining the values of temporary and deferred, as well as increasing or decreasing annuities and assurances on single lives; the tables of Mr Babbage being derived from his table of mortality in the Equitable Society, and from the Carlisle table; that of Mr Davies from the Northampton table of mortality alone.

Mr Morgan, in the statement on which those tables of Mr Babbage and Mr Davies were founded, contented himself with the use of two simple digits only, to express the proportion of the mortality in the Equitable Society to that in the Northampton table in each decade of age; and although that gentleman for twenty-five years after 1800, when that statement of the thirty years' previous observations was made, continued, in Notes on Dr Price's *Observations on Reversionary Payments*, and in his addresses to the general courts of the Equitable Society, to state that the proportions still remained the same, the

[1] See the note at the end of this Historical Introduction.

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observations extending over a period of fifty-five years, he never gave any statement more full or distinct.

These were but scanty materials certainly to construct a table of mortality from; and yet the agreement between the tables formed from them, and the best of other existing tables of mortality, is very remarkable.

A committee of the House of Commons on friendly societies having been appointed in 1827, chiefly for the purpose of inquiring into the law of mortality, and the values of life-annuities and assurances in this country, the report of that committee, by bringing the subject prominently before the public, and exciting attention to well-established but much neglected results of inquiries into it, had the effect of correcting to a considerable extent opinions upon it, taken upon trust without due examination, and generally diffused. The establishment of many new assurance companies, and the increasing prevalence of life-assurance for 15 or 20 years before, by exciting discussion and examination of their rates, had also contributed to produce that effect. At length the members of the Equitable Assurance Society, as the period of the decennial investigation of their affairs in 1829 approached, expressed a desire to avail themselves of the information respecting the law of mortality in the society which the office books might afford, for estimating and dividing their profits; and in 1828 Mr Morgan published a pamphlet entitled *A View of the Rise and Progress of the Equitable Society*, in which (p. 42) he gave the following "table of the decrements of life in the society during the preceding 12 years."

TABLE (a).

1	2	3	4
Age.	Number.	Died.	Should have died.
20 to 30	4,720	29	68
30 to 40	15,951	106	243
40 to 50	27,072	201	506
50 to 60	23,307	339	545
60 to 70	14,705	426	502
70 to 80	5,056	289	290
80 to 95	701	99	94

In the same place, the author informs his readers that "in his former statement (without mentioning which of them) he was not aware of the great number of instances in which there were several policies on one and the same life." Also that "the present is, in fact, the only correct table of the decrements of life in the society."

In the same pamphlet the author has given a table to show the law of mortality among the lives insured in the Equitable Society, founded upon his last statement; also a table of the expectations of life, and one of the values of annuities on single lives at three *per cent. per annum* interest, both derived from that table of mortality, none of them including any age under 20 years.

The author of the present article, when preparing this historical sketch, not clearly understanding the import of the numbers in the second column of this table (a), nor the last line in the table of deaths by the different diseases, given at the end of Mr Morgan's work on annuities (2d edit. 1821)—having also some doubts about the statement made in 1800—wrote to Mr Morgan, and requested the desired information respecting them, when that gentleman forwarded him the following:

1. That the second column should have been headed, "Number of persons living at the beginning of each year during the last 12 years;" and the fourth, "the number which should have died, according to the Northampton table."
2. That as to the table at the end of his treatise on annuities, he knew the numbers of deaths by the different diseases to be correct; but "the numbers in the last line of that table were those of the *policies*, which he had since found greatly to exceed the numbers of the *members*."
3. Upon his statement of 1800 Mr Morgan made no observation.

From the first part of the information thus obtained, it appears that the number in the second column on any line in table (a), is twelve times the mean number of lives in the interval of age set against it, on which the Equitable Society had policies in force during these 12 years; so that, in a society similar in all other respects, in which the law of mortality was constantly the same, and the number of lives in each interval of age was always just 12 times as great as in the Equitable during these 12 years, the population and mortality would be as in columns 2 and 3 of the following table (b).

TABLE (b).

1	2	3	4	5	6
			Of whom would die annually according to		
			Our calculations from		Mr Morgan's calculations from
Between the Ages of	Number constantly living.	Of whom die annually.	Mr Morgan's Table of Mortality in Equitable Society.	The Northampton Table of Mortality.	
20 & 30	4,720	29	37	74	68
30 & 40	15,951	106	150	299	243
40 & 50	27,072	201	337	648	506
50 & 60	23,307	339	536	780	545
60 & 70	14,705	426	664	726	502
70 & 80	5,056	289	460	461	290
80 & 95	701	99	146	147	94
Totals	91,512	1489	2330	3135	2248

If our inferences in the 4th and 5th columns of this table from Mr Morgan's *data* in the 2d and 3d be correct,[1] neither Mr Morgan's in the 6th column, nor his table of mortality, nor consequently those of the expectations and values of lives above mentioned, can have been accurately derived from the same *data*.

But even with these *data* we have reason to believe that Mr Morgan is not well satisfied, and that that gentleman has since been able to form a table from much more unexceptionable documents, which shows the probabilities

[1] It may be proper to show here, how our numbers in columns 4 and 5 have been determined. For this purpose we give as an example the manner in which the 2d in col. 5 has been calculated.

Expectation of life at $\left\{\begin{matrix} 30 = 28{\cdot}27 \times 4385 \\ 40 = 23{\cdot}08 \times 3635 \end{matrix}\right\}$ number annually attaining that age $= \left\{\begin{matrix} 123{,}964 \\ 83{,}896 \end{matrix}\right\}$ number living above $\left\{\begin{matrix} 30 \\ 40 \end{matrix}\right.$

The differences are the numbers between 30 and 40; 750 dying annually, and 40,068 constantly living.

And 40,068 : 750 : : 15,951 : 299. See article on LAW OF MORTALITY.

of life, especially in the latter periods, to be much nearer the probabilities of life among mankind in general than he had previously imagined.

It is satisfactory to find Mr Morgan at last coming into an opinion, of the truth of which, evidence had previously been adduced sufficient to convince almost all who attended to it; and, trusting that he will publish the results of his latest inquiries on the subject, we shall take no further notice here of the table of the values of annuities in his pamphlet above mentioned, which, otherwise, we could not with propriety have avoided.

Mr Morgan (*Pamph.* p. 42 and 43) asserts that a comparison of columns 3 and 6 of this table (b) affords a striking proof of the accuracy of the Northampton table; but to judge of that, we consider it is not column 6, but 5, which should be compared with column 3.

In the *Transactions of the Cambridge Philosophical Society*, vol. iii. part 1, are two papers by Mr Lubbock; the first *On the Calculation of Annuities, and on some Questions in the Theory of Chances* (read May 26, 1828); the other *On the Comparison of various Tables of Annuities* (read March 30, 1829).

In the year 1808 government commenced granting life-annuities at prices calculated from the Northampton table of mortality, and continued so to grant them for 20 years, at a great loss to the nation, especially when the lives were young, as was well known at the time to those who understood the subject; and was mentioned more than once by the author of the present article, to a very able and well-informed member of the government, not long after they commenced granting them. But none were then granted on lives under 35 years of age; and the gentleman alluded to only observed, that the applicants for annuities were principally aged persons, and it was desirable that a safe and advantageous mode of employing their savings should be afforded them. After the year 1816 those annuities were granted to persons of all ages above 21 years.

Although the *data* necessary for determining the law of mortality among the people, and the values of pecuniary interests dependent upon the continuance or the failure of human life, cannot be obtained without the active concurrence of many persons of influence and authority; yet, for all the tables containing information of that kind relative to this country, and published before the year 1829, the public were indebted to the zeal and industry, and the separate efforts, of a few individuals.

But in March 1819 Mr Finlaison was appointed by government, with all the aids they could afford him, including proper assistants, and access to the registers of the nominees in tontines, and others on whose lives annuities had been granted by government for more than a hundred years before; in which registers the exact ages at which the annuitants were nominated, and those at which they died were stated.

Thus the *data* not otherwise accessible being provided, and the labour lessened by the number of calculators employed—the expense also being defrayed by the public—at the end of ten years, viz. in March 1829, Mr Finlaison made a report to the Lords of the Treasury, which was printed by order of the House of Commons, and, in tables filling 50 folio pages, shows the rates of mortality, and the values of annuities on single lives at all ages, among many different classes of annuitants, both separate and combined; the sexes being generally distinguished both in exhibiting the law of mortality and the values of annuities.

These, from the number and accuracy of the *data*, are more valuable than any thing of the same kind that had previously been published; but it is the values of annuities only which we have to notice here.

The lives on which annuities depend will generally be somewhat better (by which we here mean, will attain to greater longevity) than the general average of the population, though probably not nearly so much better as many believe them to be. The prevailing error in the popular estimate on this subject appears to have arisen in great measure from comparing the mortality among annuitants and assured lives, with that represented to take place by tables of mortality erroneously considered to correspond with the general average of the people; while, from being constructed on erroneous principles, and from insufficient *data*, or else being derived from observations made where the mortality was and is much greater than in Britain, the mortality according to these tables was considerably greater than that which actually prevails among the bulk of the people here. Proofs of this will be found under the article LAW OF MORTALITY.

That the lives on which annuities and assurances depend cannot be so very select or so much better than the common average as has generally been supposed, might reasonably be expected on these grounds:—

1. As to annuitants.

The lives are not all chosen on account of their presumed goodness; for many persons who have no occasion to provide for others who may survive them, purchase annuities on their own lives, only that they may themselves enjoy the whole benefit of the purchase-money, both principal and interest, during their lives.

And the greatest recommendation of these lives seems to be, that they are generally prudent persons, of temperate and regular habits.

Many other persons, especially females, spendthrifts, and faithful servants, enjoy annuities bequeathed to them by their deceased relatives, masters, or mistresses, as the most eligible provision for their future comfort and security from want; and there seems little ground to suppose them to be better lives than the common average of the same age and sex.

2. In such cases as tontines, where most of the lives are selected for their presumed goodness, the best criterion probably is, hereditary longevity in the family of the nominee; but partiality for their own friends or kindred often has considerable influence in biassing the judgment of those who select them.

That they will generally be persons of good constitutions and regular habits when selected, is all that is likely to be obtained under these circumstances; and that is also the case with the average of the population in comfortable circumstances.

Whatever the constitutions and habits of annuitants may be, the annuities held by them during their own lives, by protecting them from many of the wants, cares, and anxieties which the bulk of the people are exposed to, no doubt contribute to their longevity. But where powerful motives to raise money by the sale of an annuity on a person's own life exist, it is extremely difficult to prevent him from parting with it, whatever precautions may have been taken with that view; and with it, he also loses that help to longevity.

3. Insured lives are also generally supposed to be much better than the average of the population, as it is incumbent upon the insurance offices to be cautious in selecting them.

But bad lives, by the failure of which persons interested in them would sustain loss, are most likely to be offered, and are continually offered, for insurance; and there is reason to believe that all the caution in selection which the offices in general can exercise, is necessary to keep the lives insured up to the average goodness of the bulk of the population;—supposing always that people in gene-

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In many cases of insurance, the managers who choose the lives know very little more about them than is stated by themselves or the medical attendants they refer to, and frequently they depend much on the reports of their agents in the country; but where they are in daily habits of intercourse with most of the persons whose lives they insure, or else in habits of intimacy with some who are so, they have the means of making a much better selection. That is stated to be the case with one of the London offices, and in which, accordingly, there is said to have been observed a remarkably small mortality.

For the reasons assigned above, it appears, that although lives carefully selected, with the advantage of the necessary facilities, and unmixed with others, may be considerably better than the general average, those on which annuities and assurances are granted are not, on the average, likely to be much better.

This part of the subject is also adverted to at the end of the article on the LAW of MORTALITY.

The two following Tables, A and B, show the number of Years' Purchase Annuities on Lives of different ages are worth in present money, according to MORE CORRECT Tables of Mortality.

TABLE A.

Without distinction of Sex.

RATE OF INTEREST FOUR PER CENT. PER ANNUM.

Column	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*
Description of Lives.	Nominees in the French Tontines.	Population of Carlisle and environs.	Equitable Assurance Society.	Nominees in English Tontines. Selected by Contributors.	Chosen by Lot.	The two last together.	Various combined.	Population of Sweden and Finland.	First English Tontine.
Observations began...	1690	1779	1770	1789	1789	1789	1773	1755	1693
Ended.....	1742	1787	1800	1826	1826	1826	1826	1776	1783
Years' duration	50	9	30	37	37	37	53	21	90
Greatest number of lives.....	9260+	10,517+	6344+	3518	4831	8349	18,798	4,051,116	1002
Mean number.....	5293±	8177	2522±	2860±	3920±	6780±	15,459±	2,310,160	501±
Number of deaths.....	7933+	1840	1220±	1315	1823	3138	6,679	1,401,989	1002
Table of Mortality published in.....	1746.	1815.	1827.	1829.				1783.	1829.
Constructed by.....	Deparcieux.	Milne.	Davies.	Finlaison.				Price.	Finlaison.
Age.									Age.
10	19·008	19·585	19·647	19·167	19·068	19·118	19·242	18·891	17·128	10
15	18·502	18·956	18·944	18·475	18·422	18·448	18·532	18·336	16·207	15
20	17·938	18·363	18·242	18·011	17·946	17·979	17·954	17·603	15·349	20
25	17·420	17·645	17·494	17·526	17·530	17·528	17·534	16·839	14·976	25
30	16·810	16·852	16·701	16·889	16·925	16·907	16·995	16·006	14·624	30
35	16·084	16·041	15·867	16·098	16·099	16·099	16·314	15·138	14·023	35
40	15·133	15·074	14·939	15·195	15·124	15·160	15·516	14·034	13·193	40
45	13·904	14·104	13·845	14·061	13·985	14·023	14·533	12·959	12·199	45
50	12·526	12·869	12·599	12·671	12·528	12·599	13·295	11·658	11·183	50
55	11·173	11·300	11·349	The numbers for the two classes separately were deemed insufficient at these ages.		11·163	11·915	10·320	10·141	55
60	9·713	9·663	10·052			9·772	10·491	8·789	8·836	60
65	8·039	8·307	8·635			8·308	8·896	7·328	7·342	65
70	6·394	6·709	7·167			6·729	7·316	5·783	5·823	70
75	4·945	5·239	5·670			5·122	5·837	4·534	4·456	75

TABLE B.

The Sexes distinguished.

RATE OF INTEREST FOUR PER CENT.							
	a	*b*	*c*	*d*	*e*	*f*	
	Sweden and Finland, 1755–1766. Dr Price.			British Tontines and Annuities, 1773–1826. Mr Finlaison.			
Age.	Male.	Female.	Excess in Value of a Female above a Male Life.		Male.	Female.	Age.
10	18·674	19·109	0·435	0·919	18·782	19·701	10
15	18·105	18·568	0·463	1·055	18·004	19·059	15
20	17·335	17·872	0·537	1·318	17·295	18·613	20
25	16·592	17·087	0·495	1·187	16·940	18·127	25
30	15·751	16·261	0·510	1·102	16·444	17·546	30
35	14·812	15·465	0·653	1·131	15·749	16·880	35
40	13·668	14·401	0·733	1·281	14·875	16·156	40
45	12·535	13·383	0·848	1·471	13·798	15·269	45
50	11·267	12·049	0·782	1·731	12·430	14·161	50
55	9·998	10·642	0·644	1·751	11·039	12·790	55
60	8·540	9·039	0·499	1·540	9·721	11·261	60
65	7·090	7·566	0·476	1·361	8·216	9·577	65
70	5·670	5·897	0·227	1·083	6·775	7·858	70
75	4·487	4·582	0·095	0·854	5·410	6·264	75

The three following Tables, M, N, and O, show the Values of Annuities on Lives, according to Less Correct Tables of Mortality.—All without Distinction of Sex.

M.

RATE OF INTEREST FOUR PER CENT.					
	a	*b*	*c*	*d*	
ge.	London Bills, 1742. Simpson.	Demoivre's Hypothesis, 1753. Dodson.	Northampton Table, 1783. Price.	Mort. Regrs. in France, 1806. Duvillard.	Age.
10	16·4	16·882	17·523	17·882	10
15	15·8	16·410	16·791	17·154	15
20	14·8	15·891	16·033	16·442	20
25	14·0	15·318	15·438	15·747	25
30	13·1	14·684	14·781	15·021	30
35	12·3	13·979	14·039	14·214	35
40	11·5	13·196	13·197	13·286	40
45	10·8	12·322	12·283	12·218	45
50	10·1	11·344	11·264	11·026	50
55	9·3	10·248	10·201	9·709	55
60	8·4	9·017	9·039	8·342	60
65	7·5	7·631	7·761	6·965	65
70	6·5	6·065	6·361	5·635	70
75	5·4	4·293	4·962	4·420	75

N.

FIVE PER CENT.		
	a	*b*
Age.	12 country and 3 Parisian Parishes, 1779. Dupré and St Cyran.	Northampton Table, 1783. Dr Price.
10	15·40	15.139
15	14·82	14·588
20	14·15	14·007
25	13·59	13·567
30	12·96	13·072
35	12·32	12·502
40	11·72	11·837
45	11·05	11·105
50	10·15	10·269
55	8·93	9·382
60	7·73	8·392
65	6·73	7·276
70	5·74	6·023
75	4·59	4·744

O.

SIX PER CENT.			
a	*b*	*c*	
Breslaw Bills, 1693. Halley.	Demoivre's Hypothesis, 1753. Dodson.	Northampton Table, 1783. Price.	Age.
13·44	12·839	13·285	10
13·33	12·586	12·857	15
12·78	12·301	12·398	20
12·27	11·978	12·063	25
11·72	11·610	11·682	30
11·12	11·189	11·236	35
10·57	10·704	10·705	40
9·91	10·144	10·110	45
9·21	9·492	9·417	50
8·51	8·729	8·670	55
7·60	7·831	7·820	60
6·54	6·770	6·841	65
5·32	5·508	5·716	70
	4·000	4·542	75

History.

Explanation of Table A.

The sign (+) after the number of lives and of deaths in column *a* signifies that the real number was greater than is there stated. Those stated were the numbers of the nominees in the two tontines which commenced in 1689 and 1696, the particulars of which have been given by M. Deparcieux; but he also made all the use he could of the tontine which commenced in 1734 (less than eight years before his observations terminated), without stating any of the numbers in his essay. And whatever may have been the whole number of nominees, or of their deaths, which he availed himself of in this tontine, M. Deparcieux's observations were actually made on so many more than 9260 nominees, and 7933 deaths, among them.

The number of persons living in the two Carlisle parishes at the end of the observations was 8677; but besides them, the observations were made upon the 1840 persons who died in the place in the term of nine years during which they were continued; and these numbers together amount to 10,517, the greatest number stated in column *b*. But the real number the observations were made upon was greater still, by the number who left the place and did not return during the observations, which is the reason of the mark (+) being put after 10,517 in column *b*.

For information respecting the number of lives insured, and of deaths, in the Equitable Assurance Society, given at the head of column *c*, the reader is referred to the note at the end of this historical introduction.

The better to enable the reader to judge of the comparative extent of the observations made upon the nominees in tontines, and other annuitants, by M. Deparcieux and Mr Finlaison, and of those made upon the population of the two Carlisle parishes, the lives insured in the Equitable Society, and the population of Sweden and Finland, the mean number of living annuitants has been assumed to have been an arithmetical mean proportional between the numbers of them at the commencement and at the end of the term, which can only be precisely true if they died off by equal numbers in equal times; and that is the reason why the double sign (±) has been placed after the mean number of the nominees or other annuitants in each column. Thus 2860± in column *d* shows that the mean number of living nominees of that description was 2860 *more or less*. The deviation from precision in this case is of no importance.

The values in column *a* have been taken from the work on Annuities of Mr Baron Maseres; those in columns *d* and *e* from Mr Finlaison's report (obs. 4 and 5); that in column *f* at each age to 50 inclusive is a mean between those in columns *d* and *e*;—after 50 they are taken from Mr Finlaison's 5th observation. The value in column *g* at each age is a mean between the two against the same age in columns *e* and *f* of table B; the values in column *i* are from Mr Finlaison's first observation.

Of Table B.

The values in columns *e* and *f* have been taken from the 20th and 13th observations respectively in Mr Finlaison's report, and were calculated from the rates of mortality for the two sexes, which have been adopted for use by government.

They were deduced from observations on the mortality among the nominees in the three Irish tontines which commenced in 1773, 1775, and 1778 respectively, on the tontine of 1789, and those of the sinking fund from 1808 to 1822.

It will be observed that the excess of the value of an annuity on a female life above that of a male is, according to the table for Sweden, in many cases not half, and in some less than one third as much as according to Mr Finlaison's, derived from the government annuitants. The cause of this cannot but be an object of interest, and deserves further investigation. It may arise in great measure from the ages of many females being stated below the truth in the Swedish returns, while they were accurately ascertained among the government annuitants.

Of Tables M, N, *and* O.

The values according to Demoivre's hypothesis were taken from Dodson's *Mathematical Repository* (vol. ii. p. 169); those in column *d* of table M, founded upon Duvillard's table of mortality for France before the Revolution, published in his work on the *Mortality from Small-Pox* (4to, Paris, 1806), were taken from *The Doctrine of Compound Interest* by M. Corbaux (8vo, London, 1825); the values according to Dupré and St Cyran from the *Calculs des Rentes Viagères* of the latter.

The authorities for the rest appear sufficiently from the preceding historical sketch.

The values of annuities according to M. Kersseboom's table of mortality are not given here, that table being of doubtful character, as he neither published the whole of the *data* from which he formed it, nor explained the manner of its construction.

It would have been desirable to include the values according to the tables of Dr Halley for Breslaw, and Dupré de St Maur for the Parisian and French country parishes in table M; but as the values of annuities have not been calculated from these tables at four *per cent.*, we have added tables N and O, and have given in each of them the values from the Northampton table, with the view of facilitating the comparison of the values in N and O with those in M and A.

Observations on the above Tables.

All the tables of mortality from which the values of annuities in tables M, N, and O, have been deduced, were calculated from *bills of mortality alone* of places where the population was variable, and the numbers of the people at the different ages were not ascertained. And therefore, notwithstanding the attempts to supply their defects, which were made by the eminent mathematicians who constructed them, none of them represented truly the laws of mortality in the places where the respective observations were made; as will be evident to those who understand the article on the *Law of Mortality* in this work, and pay the necessary attention to the materials and manner of construction of those tables. Consequently the values of annuities derived from them cannot be correct, but will in general be considerably less than the truth, even for the general average of the whole population of the places in which the observations were made.

But those values of annuities are also objectionable on this ground—that the places they were intended for, and understood to be adapted to, were generally populous towns, containing a large proportion of poor persons dependent upon their daily labour for their supply of food from day to day, often with little forethought, and many of them engaged in unwholesome employments, amongst whom great distress is often endured by the comparatively high prices of bread and potatoes, or the low rate of wages, when the unwholesome and scanty food they are reduced to produces typhus fever, and sometimes the dysentery among them, which carry them off in great numbers. And these visitations were much more common at the times when the observations were made from which most of those tables were constructed, than they have been of late years.

None of those causes of mortality operate sensibly upon the general average of those persons upon whose lives leases or annuities, and reversions or assurances, depend, they being generally in the higher and middle classes. Neither do they produce much effect among the more deserving persons in the lower class, such as the members of friendly societies, and others who are both industrious and frugal enough to live within their incomes; nor indeed upon any who are in comfortable circumstances.

Hence it follows that the values of life-annuities, and, consequently, those of any pecuniary interests dependent upon the continuance or the failure of human life, cannot be correctly determined from observations made on a whole population similar to those of the places these tables were constructed from.

But this was not distinctly seen till of late years, and appears to be very imperfectly understood at present (in the year 1830), even by some who might be expected to possess correct information on the subject.

The tables constructed by Dr Price, both from the Swedish observations, and those made by Dr Haygorth at Chester, threw valuable light on this subject. But deficient crops in Sweden operate powerfully in raising the mortality there, in comparison with the more fruitful parts of Europe; therefore, the values of annuities copied into table B, and col. *h* of table A, from Dr Price's work, must only be understood as sufficiently correct for the period and place in which the observations were made. And the Chester table is in some degree liable to the same objections as the others above mentioned.

On Table A.

For nearly 70 years after its publication, M. Deparcieux's table, from which the values given in col. *a* of table A were derived, was the only one from which the values of life-interests and of reversions depending upon lives could be determined with considerable accuracy. But the comparatively high values of annuities according to that table were always supposed to arise from the careful selection of the lives; notwithstanding that they were almost all inhabitants of Paris and its environs.[1] At that time (1689–1696) the Parisians were much worse lives than during the last 50 years, and a judicious selection was much less likely to be made then than now.

It is to be regretted that the Carlisle observations were only continued nine years, commencing with 1779; but the less so since Mr Milne has shown in his work on annuities (p. 429), that during the term of 22 years commencing with 1779, the proportion of the annual average number of deaths to the mean number of the people was the same as in these first nine years, viz. that of 1 to 40.

In comparing the values in column *c* of table A with the rest, it should be borne in mind that a great majority of insured lives are males, on which account the values are somewhat lower, especially from 15 to 55 years of age, than they would have been had there been nearly equal numbers of both sexes.

Columns *d* and *e* are very instructive. In the session of 1789, an act (29 Geo. III. cap. 41) was passed for raising the sum of L.1,002,500 by the sale of shares in a tontine; but the scheme did not succeed, the persons who in the first instance had taken the whole of the shares with the expectation of selling them at a profit not having been able to dispose of half of them; and to afford those persons relief, an act (30 Geo. III. cap. 45) was passed in the next session, allowing them, before the 20th September of that year (1790), to exchange each of the tontine shares they had not been able to dispose of, for an annuity-certain payable during 69¼ years. And in order that those who had taken shares, and fixed upon their nominees in the tontine, might be placed in the same situation with regard to the benefit of survivorship as if the scheme had completely succeeded, this act empowered the commissioners of the treasury to select tontine nominees for the exchanged shares, from *the Peers of Great Britain and Ireland, their children or grandchildren; baronets, lords of manors, justices of the peace in England and Wales, or their children; the dignitaries of the church or beneficed clergy, fellows of colleges, the governors of the Charter House, the Foundling Hospital, or Christ's Hospital, and those who were registered in the books of the Amicable Life Assurance Society.*

The commissioners of the treasury were to distribute their nominees into six classes according to their ages, in proportion to the nominees of the contributors in the same classes. Tickets with the names of the nominees were then to be put into six boxes, set apart for the respective classes, and drawn out till a sufficient number to complete the tontine was obtained for each class. All of which was performed accordingly.

The values of annuities on the lives chosen by the contributors are given in col. *d*, on those thus drawn by lot in col. *e*, and the two combined in col. *f*.

Thus it appears that, of the lives in col. *e*, there was no selection except their being taken from the descriptions of persons above mentioned, who were all in the upper or middle classes of society. But, as might have been anticipated, a considerable majority of female lives were chosen by the contributors, and a considerable majority of males were drawn by the commissioners of the treasury, the descriptions of persons they were restricted to, consisting principally of males.

It will be observed that the values in columns *d* and *e* agree very nearly:—they would probably have agreed better still had the proportion of the two sexes been the same in both.

And this shows how little advantage the contributors derived from choosing their nominees, beyond what was secured to them by the classes of society they were selected from.

The values of annuities in column *i* are much less than in any other of table A; they are even less than those derived from the Northampton table of mortality.

But it would be equally precipitate and unphilosophical to conclude from thence, without further investigation, that the bulk of the people of England 100 years ago were so much shorter lived than they are now.

That the prolongation of life among the bulk of the population, from and after every age, has been very considerable during the last century, no unprejudiced person who has paid sufficient attention to the subject to qualify himself for judging of it can entertain a doubt; or that it has also been somewhat lengthened among the upper and middle classes of society; but not nearly to the extent which a comparison of columns *g* and *i* of table A would seem to imply.

There is certainly no rational ground for supposing that the physical constitution of man has altered: any change that has taken place can only have been produced by changes in the habits of the people, and the circumstances in which they have been placed.

All this might have been reasonably concluded in the absence of further information; but an examination of the circumstances under which the tontine of 1693 was

[1] As M. Deparcieux states in his *Essai*, p. 62.

History. formed, and of the first observation in Mr Finlaison's report, from which the values in col. *i* have been deduced, will confirm it.

In that year, the same in which Dr Halley's paper on the Breslaw Bills was published in the *Philosophical Transactions*, this branch of knowledge was in its infancy. By the 22d section of the act (4 William and Mary, cap. 3) for raising a million of money by the sale of shares in this tontine, it was enacted that, if the sale of the tontine shares did not produce the whole sum wanted by the first of May 1693, then between that day and the 29th September following, for any sum contributed towards the completion of the million, the contributor should receive 14 *per cent. per annum* on such sum during the life of any person he might choose to nominate; the common interest of money at that time being 6 *per cent. per annum*. And by an act passed in the next session (5 William and Mary, cap. 5), the term for granting annuities on these terms, and for the same purpose, was extended to the 1st of May 1694. This was selling annuities at half their true value.

The age of a nominee is never mentioned in either of these acts, and those in the tontine were not distinguished into classes. These things were, at the same time, managed better in France.

Even Dr Halley was not aware of the greater mortality of males, and the consequent greater proportion of females in the population, as appears by his paper above mentioned; for after calculating from his table of mortality the number of inhabitants in Breslaw between 18 and 56 years of age to be 18,053, he says, "at least one half of these are males."

The contributors to the tontine could not be expected to be better informed on these subjects than the parliament and Dr Halley; and, with respect to ages and sexes, the following appears by Mr Finlaison's statement to have been their selection of nominees.

Aged.	Number of		
	Males.	Females.	Both.
Under 6	178	113	291
Between 6 and 11	178	118	296
Under 11	356	231	587
Between 11 and 16	119	96	215
Under 16	475	327	802
Between 16 and 21	49	39	88
Under 21	524	366	890
Above that age	70	42	112
Total	594	408	1002

In the absence of better information, it would seem reasonable to conclude that the younger a life was, the longer it would be likely to last; and accordingly we find that more than half the lives were under 11 years of age at the time of their nomination. And as males are more robust than females, it was also natural to conclude that a less rate of mortality would prevail among them; and accordingly three fifths of the nominees were males.

But subsequent observations have shown that, in both instances, the contributors made a bad choice.

Besides, of all the nominees, only one ninth had completed their 21st year at the time of their nomination. Not only the constitutions of these young nominees were not then fully formed or developed, but the mortality among them would depend greatly upon their destiny in after-life, or the circumstances of their respective situations, and upon their moral conduct: all of which must be very uncertain, and difficult to judge of at such early ages. His.

It is not improbable, too, that, on account of their beauty and healthy appearance, many children of scrofulous constitutions were selected; and they, on an average, would be short-lived.

It is probable that a great majority of the contributors, and therefore of their nominees, resided in London or other large and crowded towns, which have always been peculiarly unfavourable to the health of children, but were much more so then than they are now.

All circumstances considered, there appears sufficient evidence to show that the mortality among these nominees must have been much greater than among the general average of selected lives, or the general average of the people in comfortable circumstances at that time; and that, if the nominees in the English tontine of 1693 had been distributed into classes according to their ages, and a larger annuity for the same purchase-money had been allowed to the older classes, always with benefit of survivorship, the lives would have been more judiciously chosen, and would not probably have differed materially from the nominees in the French tontines of 1689 and 1696, which M. Deparcieux's observations were made upon,—they, it has been shown, were but little inferior in goodness to our present annuitants and insured lives.

The values of annuities on single lives given in Mr Finlaison's report are only specimens at one rate of interest of the results of calculations made at several rates. And extensive calculations have also been made at the Government Life-Annuity Office, of the values of annuities on two and on three joint lives, with distinction of the sexes. But none of these have been published, nor do they now (in July 1830) at that office grant any annuity depending upon more than one life, nor expect to do so for two or three years to come.

In this country, cases are continually occurring, in which an equitable adjustment of the rights and interests of different parties in property depending upon the continuance or the failure of human life, is of great importance; and in many cases it cannot be made with sufficient accuracy without tables of the values of all possible combinations of two and even of three joint lives of different ages and of both sexes. But not unfrequently, especially in cases of contingent reversions, we have been hitherto, and are still, obliged to use approximations to the values of all the possible combinations of the lives involved, not only with each other, but also of them with others one year younger than each of them respectively. In these cases it sometimes happens that the whole value sought, being but a small part of a year's purchase, is less than the probable error of several of these approximations considered separately; and then it is very difficult to give with confidence even a near approximation to the value sought.

But in a great many other cases of frequent occurrence and less difficulty, the want of a complete set of good tables of this kind is much felt. It is therefore highly desirable that, numerous calculations for them having been made at the expense of the public, they should be completed at the public expense, and rendered accessible to persons having occasion to use them; by printing, if the expense would not be too great; otherwise, by having several manuscript copies accurately made, and deposited in convenient places for inspection, upon payment of a small fee.

A few writers on these subjects, of late years, have employed the differential and integral calculus in their in-

vestigations. We have not yet seen any fruits of this application of the calculus which appear to us of much value, nor are we at all sanguine in expecting any.

Although Lambert and Duvillard had made some efforts in this way before, Laplace (in his *Théor. Anal. des Probabilités*, No. 40) was the principal writer who thus treated the subject, and that very shortly, merely touching upon the elements. He arrived in the usual manner at the same formulæ that are given in the elementary algebraic method, and are here demonstrated by common arithmetic; only expressed in the manner of the higher calculus, in terms of the absciss and ordinate of the curve of mortality, both considered as variable quantities.

He judiciously observed that the integral might be obtained in every case by calculating all its terms from a table of mortality, and taking their sum; and that in this manner tables of the values of annuities on single and joint lives might be calculated; which is only reverting to the usual method.

But he also observed that the same thing might be effected by describing a parabolic curve through the vertices of the two extreme and several intermediate ordinates of the curve of mortality, and even that a few of these would be sufficient, since the differences between the different tables of mortality would justify us in considering that method to be equally exact with those tables themselves. And in this we should entirely concur with that profound mathematician, provided we could admit that those tables, or most of them, had equal titles to our confidence, which he appears tacitly to assume.

But here it is that M. Laplace appears to us to have fallen into the same error as most others respecting those tables of mortality, from not having paid sufficient attention to the data they were constructed from, and the manner of their construction.

After what has been advanced in this article, and in that on the *Law of Mortality* in this work, we think it quite unnecessary to say more here, than that we consider it an established truth, that tables of mortality well constructed from proper *data*, for determining the values of annuities and reversions, do not differ materially from each other.

If imperfect data for constructing a table of mortality be obtained, and any one already constructed, or the mean of several of them, be taken as a pattern or standard, to which it is desired that the new table should approach, it will not be difficult, by the known methods of approximation and interpolation, so to construct such new table that it shall not differ much from the standard; but such new table, being in a certain degree hypothetical, can be of little or no value.

According to the usual methods of treating these subjects, and constructing accurate tables, we never depart from the observations, but are supported by them at every step: our clear and simple methods of reasoning and calculation are much superior to the data we can obtain: proper data are alone wanting to further the science at present; government only can effectually supply them, and all who take any interest in these subjects must be grieved to find that there is little or no hope of assistance from that quarter. Even if a wiser course be adopted in future, 20 years more must elapse before we can reap the benefit of it.

This is not the proper place to enter further into that part of the subject; but to those who take an interest in it, we would recommend the perusal of the minutes of evidence taken before the committee on the population bill, ordered by the House of Commons to be printed 11th May 1830; and the minutes of the committee on the recommitted bill, printed 26th May 1830; especially, in the latter, Mr Milne's letter to Mr Davies Gilbert, the chairman, in answer to an application made to him for his opinion, with Mr Rickman's marginal notes on that letter, and his observations on it in *his* letter to the chairman, which Mr Milne knew nothing of till the bill was passed.

NOTE REFERRED TO IN TWO PLACES ABOVE.

According to Mr Morgan's statements in the places here referred to, the number of members, or of assurances, or of policies, found to be in the Equitable Assurance Society, was—

At the end of the year			Reference to Mr Morgan's Statement.
1768	564	Policies	View of Rise and Progress, &c. p. 10.
1770	490	Policies	Ditto ditto.
1772	500+	Members	Ditto p. 27.
1773	734	Members	Address of 7th March 1793 p. 118.[1]
1776	913	Policies	Ditto of 24th April 1800 p. 140.
1783	1608	Members	Ditto of 7th March 1793 p. 118.
1786	2100+	Members	Ditto of 24th April 1800 p. 140.
1792	4640	Assurances	View of Rise and Progress, &c. p. 24.
1799	5124	Members	Ditto p. 26.

From which we infer, that if, at the end of each year, beginning with 1770, and ending with 1799, the number had been taken, the sum of all the 30 would have been 75,664, and the mean number during these 30 years 2522.

In a note on p. 443, vol. ii. of Dr Price's *Obs. on Rev. Paym.* (7th edit.), Mr Morgan states, that during 33 years, from January 1768 to January 1801, the number of assurances on single lives had been 83,201; but this great number can only be the sum of the 33 annual numbers as above mentioned, and the mean of these will be 2521.

What we wish to know is, the mean number of lives insured on which policies were in force during the observations; but that Mr Morgan never mentions. As more policies than one are not unfrequently granted for so many distinct assurances on the same life, neither the number of policies nor of assurances will answer our purpose; neither will the number of members, for if a policy be granted to A for insurance on the life of B, A is the member of the society, and not B, who is only the life assured, and several other members besides A may insure the life of B, while A may also hold more policies than one insuring B's life.

As has been already observed, Mr Morgan has repeatedly stated that the rate of mortality in the Equitable Society has always continued the same. And by tables *a* and *b* it appears, that out of 91,512 living persons in a similar society above 20 years of age, 1489 would die annually; also, in the table at the end of Mr Morgan's annuities (2d ed.), it is stated, that during the first 20 years of the 19th century, 1923 of the lives assured in the society died above 20 years of age; but 1489 : 1923 :: 91,512 : 118,185, so that this last is the number of lives in a similar society, out of which these 1923 deaths would happen in one year.

[1] These addresses are printed at the end of the deed of settlement of the society, for the use of the members: the copy quoted from was printed in 1801.

History. Then supposing, what is probably near the truth, that under 10 years of age the number of policies was the same as that of the lives insured, we shall have, by the statement last mentioned,

	Number of Lives.	Number of Annual Deaths.
Between 10 and 20 years of age	1,494	7
Above 20	118,185	1923
Above 10 years of age	119,679	1930

And $\frac{119,679}{20} = 5984$ is the mean number above 10. That is, a population falling short of 6000, instead of exceeding 150,000, as stated by Mr Morgan.

But by the table above mentioned in Mr Morgan's work on annuities, and the explanations of it given above, it appears that by 151,754 policies in force in the society,

119,679 lives were insured;

and 119,679 : 151,754 :: 7 : 9 nearly (more nearly :: 11 : 14). So that the number of lives was to that of the policies as 7 to 9 nearly, during the twenty years ending with 1820.

On p. 61 of his pamphlet *On the Rise and Progress of the Equitable Society*, Mr Morgan states the proportion in 1827 to have been that of 3 to 4 nearly; and from another statement of his in a note on p. 42 of the same pamphlet, it would appear to have been that of 5 to 6 during the 12 years ending with 1827. The proportion above stated is nearly a mean between these two.

Taking the mean number of lives on which assurances were in force in the Equitable Society during the last 30 years of the eighteenth century to have been 2522, as determined above; since 119,679 : 2522 : : 1930 : 40·671, this last is the annual average number of deaths in the society during these 30 years; therefore the whole number of them must have been 1220, which being added to 5124, the greatest number living at any one time during the term (that is, at the end of 1799, as stated above), the sum is 6344. And the greatest number of lives on which Mr Morgan's observations were made during that term must have exceeded this, by the number who went out of the society by sale or forfeiture of the assurances, or by the expiration of the limited terms some of them were granted for, and did not enter it again; wherefore the sign (+) is added as before in table A.

In treating of ANNUITIES, we think that it may be useful in a work of this kind to address ourselves as well to those readers who have not, as to those who have, an acquaintance with *Algebra;* and we shall accordingly divide what follows into two Parts, corresponding to these two views of the subject.

PART I.

We shall in this Part demonstrate all that is most useful and important in the doctrine of annuities and assurances on lives, without using algebra or introducing the idea of probability; but the reader is of course supposed to understand common arithmetic. In the first 30 numbers of this Part, *compound interest* and *annuities-certain* are treated of; from the 31st to the 76th the doctrine of *annuities on lives* is delivered; and that of *assurances* on lives from thence to the 108th, where the popular view terminates.

What is demonstrated in this Part will be sufficient to give the reader clear and scientific views of the subjects treated, and, with the assistance of the necessary tables, will enable him to solve the more common and simple problems respecting the values of annuities and assurances. He will also understand clearly the general principles on which problems of greater difficulty are resolved; but these he cannot undertake with propriety when the object is to make a fair valuation of any claims or interests, with a view to an equitable distribution of property, unless he has studied the subject carefully, with the assistance of algebra; for intricate problems of this kind can hardly be solved without it; and those who are not much exercised in such inquiries often think they have arrived at a complete solution, while they have overlooked some circumstance or event, or some possible combination of events or circumstances, which materially affects the value sought. Eminent mathematicians have in this way fallen into considerable errors, and it can hardly be doubted that those who are not mathematicians must (*cæteris paribus*) be more liable to them.

I.—ON ANNUITIES-CERTAIN.

No. 1. When the rate is 5 *per cent.*, L.1 improved at simple interest during one year will amount to L.1·05; which, improved in the same manner during the second year, will be augmented in the same ratio of 1 to 1·05: the amount then will therefore be $1·05 \times 1·05$, or $(1·05)^2 = 1·1025$.

In the same manner it appears that this last amount, improved at interest during the third year, will be increased to $(1·05)^3 = 1·157625$; at the end of the fourth year it will be $(1·05)^4$; at the end of the fifth $(1·05)^5$, and so on; the amount at the end of any number of years being always determined by raising the number which expresses the amount at the end of the first year to the power of which the exponent is the number of years. So that when the rate of interest is 5 *per cent.*, L.1 improved at compound interest will in seven years amount to $(1·05)^7$, and in 21 years to $(1·05)^{21}$.

But if the rate of interest were only 3 *per cent.*, these amounts would only be $(1·03)^7$ and $(1·03)^{21}$ respectively.

2. The present value of L.1 to be received certainly at the end of any assigned term, is such a less sum as, being improved at compound interest during the term, will just amount to one pound. It must therefore be less than L.1, in the same ratio as L.1 is less than its amount in that time; but in three years at 5 *per cent.* L.1 will amount to L.$(1·05)^3$ (1). And $(1·05)^3 : 1 : : 1 : \frac{1}{(1·05)^3}$; so that $\frac{1}{(1·05)^3} = \frac{1}{1·157625} = 0·863838$ is the present value of L.1 to be received at the expiration of three years.

In the same manner it appears that, at 4 *per cent.* interest, the present value of L.1 to be received at the end of a year is $\frac{1}{1·04} = 0·961538$; and if it were not to be received until the expiration of 21 years, its present value would be $\frac{1}{(1·04)^{21}} = (0·961538)^{21} = 0·438834$.

Hence it appears, that if unit be divided by the amount of L.1 improved at compound interest during any number of years, the quotient will be the present value of L.1 to be received at the expiration of the term; which may also be obtained by raising the number which expresses the present value of L.1 receivable at the expiration of a year, to the power of which the exponent is the number of years in the term.

3. When a certain sum of money is receivable annually, it is called an *Annuity*, and its *quantum* is expressed by saying it is an annuity of so much; thus, according as the annual payment is L.1, L.10, or L.100, it is called an annuity of L.1, of L.10, or of L.100.

4. When the annual payment does not depend upon any contingent event, but is to be made certainly, either in perpetuity or during an assigned term, it is called an *Annuity-certain*.

5. In calculating the value of an annuity, the first payment is always considered to be made at the end of the first year from the time of the valuation, unless the contrary be expressly stated.

6. The whole number, and part or parts of one annual payment of an annuity, which all the future payments are worth in present money, is called *the number of years' purchase* the annuity is worth, and, being the sum of the present values of all the future payments, is also the sum which, being put out and improved at compound interest, will just suffice for the payment of the annuity. (2.)

7. Hence it follows, that when the annuity is L.1, the number of years' purchase and parts of a year is the same as the number of pounds and parts of a pound in its present value.

And throughout this article, whenever the *quantum* of an annuity is not mentioned, it is to be understood to be L.1.

8. The sum of which the simple interest for one year is L.1, is evidently that which, being put out at interest, will just suffice for the payment of L.1 at the end of every year, without any augmentation or diminution of the principal, and, being equivalent to the title to L.1 *per annum* for ever, is called the *value of the perpetuity*, or the number of years' purchase the perpetuity is worth.

But while the rate remains the same, the annual interests produced by any two sums are to each other as the principals which produce them; therefore, since $5 : 1 :: 100 : \frac{100}{5} = 20$, when the rate of interest is 5 *per cent.*, the value of the perpetuity is 20 years' purchase. In the same manner it appears, that according as the rate may be 3 or 6 *per cent.*, the value of the perpetuity will be $\frac{100}{3} = 33\frac{1}{3}$, or $\frac{100}{6} = 16\frac{2}{3}$ years' purchase; and may be found in every case, by dividing any sum by its interest for a year.

9. All the most common and useful questions in the doctrines of compound interest and annuities-certain may be easily resolved by means of the first four tables at the end of this article. Their construction may be explained by the following specimen, rate of interest 5 *per cent.*

CONSTRUCTION OF					
	Table IV.	Table III.	Table I.	Table II.	
	Amount of L.1 *per annum*	Amount of L.1	Present value of L.1 to be received at	Present value of L.1 *per annum*, to be received until	
Term.	improved at Interest until				Term.
	the Expiration of the Term.				
1 yr.	1·000000	1·050000	·952381	0·952381	1 yr.
2 yrs.	2·050000	1·102500	·907029	1·859410	2 yrs.
3	3·152500	1·157625	·863838	2·723248	3
4	4·310125	1·215506	·822702	3·545950	4
5	5·525631	1·276282	·783526	4·329476	5
6	6·801913	1·340096	·746215	5·075691	6
7	8·142009	1·407100	·710681	5·786372	7

10. The calculation must begin with Table III., the first number in which should evidently be 1·05, the amount of L.1 improved at interest during one year, which being multiplied by 1·05, the product is 1·025, the second number. This second number being multiplied by 1·05, the product is 1·157625, the amount at the end of three years. And so the calculation proceeds throughout the whole of the column; each number after the first being the product of the multiplication of the preceding number, by the amount of L.1 in a year. (1.)

11. The number against any year in Table I. is found by dividing unit by the number against the same year in Table III. (2); thus, the number against the term of six years in Table I. is $\frac{1}{1{\cdot}340096} = {\cdot}746215$. All the numbers in that table after the first may also be found by multiplying that first number continually into itself. (2.)

12. The number against any year in Table II., being the sum of the numbers against that and all the preceding years in Table I., is found by adding the number against that year in Table I. to the number against the preceding year in Table II.; thus, the number against four years in Table II. being

the sum of 0·822702
and 2·723248

is 3·545950.

13. If each payment of an annuity of L.1 be put out as it becomes due, and improved at compound interest during the remainder of the term, it is evident that at the expiration of the term the payment then due will be but L.1, having received no improvement at interest. That received one year before will be augmented to the amount of L.1 in a year; that received two years before will be augmented to the amount of L.1 in two years; that received three years before to the amount of L.1 in three years; and so on until the first payment, which will be augmented to the amount of L.1 in a term one year less than that of the annuity.

Hence it is manifest that the number against any year in Table IV. will be unit added to the sum of all those against the preceding years in Table III.

And therefore that the number against any year in Table IV. is the sum of those in Tables III. and IV. against the next preceding year.

Thus, the number against seven years in Table IV. being

the sum of 1·340096
and 6·801913

is 8·142009.

14. The method of construction is obviously the same at any other rate of interest.

15. All the amounts and values which are the objects of this inquiry evidently depend upon the improvement of money at compound interest; it is therefore, that the first, second, and fourth tables, all depend upon the third.

But every pound, and every part of a pound, when put out at interest, is improved in the same manner as any single pound considered separately. Whence it is obvious, that while the term and the rate of interest remain the same, both the amount and the present value, either of any sum or of any annuity, will be the same multiple, and part or parts of the amount or the present value found against the same term, and under the same rate of interest in these tables, as the sum or the annuity proposed is of L.1.

So that to find the amount or the present value of any sum or annuity for a given term and rate of interest, we have only to multiply the corresponding tabular value by

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the sum or the annuity proposed; the product will be the amount or the value sought, according as the case may be.

16. *Example* 1. To what sum will L.100 amount when improved at compound interest during 20 years, the rate of interest being 4 *per cent. per annum?*

By Table III. it appears that L.1 so improved would, at the expiration of the term, amount to L.2·191123; therefore L.100 would amount to 100 times as much, that is, to L.219·1123, or L.219. 2s. 3d.

17. *Ex.* 2. What is the present value of L.400, which is not to be received until the expiration of 14 years, when the rate of interest is 5 *per cent.?*

The present value of L.1 to be received then will be found by Table I. to be L.0·505068: L.400 to be received at the same time will therefore be worth, in present money, 400 times as much, or L.202·0272, that is, L.202. 0s. 6½d.

18. *Ex.* 3. Required the present value of an annuity of L.50 for 21 years, when the rate of interest is 5 *per cent.*

Table II. shows the value of an annuity of L.1 for the same term to be L.12·8212; the required value must therefore be 50 times as much, or L.641·06, that is L.641. 1s. 2½d.

19. *Ex.* 4. What will an annuity of L.10. 10s. or L.10·5 for thirty years amount to, when each payment is put out as it becomes due, and improved at compound interest until the end of the term; the rate of interest being 4 *per cent.?*

The amount of an annuity of L.1 so improved would be L.56·084938, as appears by Table IV.; the amount required will therefore be 10·5 times this, or L.588·89185, that is L.588. 17s. 10d.

20. When the interval between the time of the purchase of an annuity and the first payment thereof exceeds that which is interposed between each two immediately successive payments, such annuity is said to be *deferred* for a time equal to that excess, and to be *entered upon* at the expiration of that time.

21. If two persons, *A* and *B*, purchase an annuity between them, which *A* is to enter upon immediately, and to enjoy during a certain part of the term, and *B* or his heirs or assigns for the remainder of it, the present value of *B's* interest will evidently be the excess of the value of the annuity for the whole of the term from this time, above the value of the interest of *A*.

So that when the entrance on an annuity is deferred for a certain term, its present value will be the excess of the value of the annuity for the term of delay and continuance together, above the value of an equal annuity for the term of delay only.

22. *Example* 1. Required the value of a perpetual annuity of L.120, which is not to be entered upon until the expiration of 14 years from this time, reckoning interest at 3 *per cent.*

The perpetuity, with immediate possession, would be worth 33⅓ years' purchase (8); and an annuity for the term of delay is worth 11·2961 (Table II.)

From	33·3333
subtract	11·2961, and multiply
the remainder	22·0372
by	120

the product, 2644·464 = L.2644. 9s. 3¼d., is the required value.

23. *Ex.* 2. Allowing interest at 5 *per cent.*, what sum should be paid down now, for the renewal of 14 years lapsed in a lease for 21 years of an estate producing L.300 *per annum*, clear of all deductions?

This is the price of an annuity for 14 years, to be entered upon 7 years hence; the term of delay, therefore, is 7 years, and that of the delay and continuance together 21 years.

By Table II. it appears, that the present value of an annuity

for 21 years, is	12·8212	years' purchase.
for 7 years,	5·7864	
Value of the deferred annuity,	7·0348	
Multiply by	300	
The product,	L.2110·44, or L.2110. 8s. 9½d.,	

is the price required.

24. Hitherto we have proceeded upon the supposition of the annuity being payable, and the interest convertible into principal, which shall reproduce interest, only once a year.

But annuities are generally payable half yearly, and sometimes quarterly; and the same circumstances that render it desirable for an annuitant to receive his annual sum in equal half-yearly or quarterly portions, also give occasion to the interest of money being paid in the same manner.

But whatever has been advanced above concerning the present value or the amount of an annuity, when both that and the interest of money were only payable once a year, will evidently be true when applied to half the annuity and half the interest paid twice as often, on the supposition of half-yearly payments; or to a quarter of the annuity and a quarter of the interest paid four times as often, when the payments are made quarterly.

25. Half-yearly payments are, however, by far the most common; and these four tables will also enable us to answer the most useful questions concerning them.

For we have only to extract the present value, or the amount, from the table, against twice the number of years in the term, at half the annual rate of interest, and, in the case of an annuity, to multiply the number so extracted by half the annuity proposed.

26. *Ex.* 1. To what sum will L.100 amount in 20 years, when the interest at the rate of 4 *per cent. per annum* is convertible into principal half-yearly?

This being the amount in 40 half years at 2 *per cent.* interest for every half year, will be the same as the amount in 40 years at 2 *per cent. per annum*, which, by Table III. will be found to be 220·804, or L.220. 16s. 1d.; and is only L.1. 13s. 10d. more than it would amount to if the interest were not convertible more than once a year. (16.)

27. *Ex.* 2. What is the present value of an annuity of L.50 for 21 years, receivable in equal half-yearly payments, when money yields an interest of 2½ *per cent.* every half year?

By Table II. it appears, that an annuity of L.1 for 42 years, when the interest of money is 2½ *per cent. per annum*, will be worth L.25·8206 (25); 25 times this sum, or L.645. 10s. 3½d., is therefore the required value, and exceeds the value when the interest and the annuity are only payable once a year, by L.4. 9s. 1d. (18.)

28. The excess of an annuity-certain above the interest of the purchase-money, is the sum which, being put out at the time of each payment becoming due, and improved at compound interest until the expiration of the term, will just amount to the purchase-money originally paid.

But, while every thing else remains the same, the longer the term of the annuity is, the less must its excess above the interest of the purchase-money be, because a less annuity will suffice for raising the same sum within the term. Therefore, the proportion of that excess to the annual interest of the purchase-money continually diminishes as

the term is extended; and when the annuity is a perpetuity, there is no such excess. (8.)

29. The reason why the value of an annuity is increased by that and the interest being both payable more than once in the year, is, that the granter loses and the purchaser gains the interest produced by that part of each payment which is in excess above the interest then due upon the purchase-money, from the time of such payment being made until the expiration of the year.

Hence it is obvious, that the less this excess is, that is, the longer the term of the annuity is (28), the less must the increase of value be.

And when the annuity is a perpetuity, its value will be the same, whether it and the interest of money be both payable several times in the year, or once only.

30. When the annuity is not payable at the same intervals at which the interest is convertible into principal, its value will depend upon the frequencies both of payment and conversion; but its investigation without algebra would be too long, and of too little use, to be worth prosecuting here.

II.—Of Annuities on Lives.

31. When the payment of an annuity depends upon the existence of some life or lives, it is called a *Life-Annuity*.

32. The values of such annuities are calculated by means of tables of mortality, which show, out of a considerable number of individuals born, how many upon an average have lived to complete each year of their age, and, consequently, what proportion of those who attained to any one age have survived any greater age.

The fifth table at the end of this article is one of that kind which has been taken from Mr Milne's *Treatise on Annuities*, and was constructed from accurate observations made at Carlisle by Dr Heysham, during a period of nine years, ending with 1787.

33. By this table it appears, that during the period in which these observations were made, out of 10,000 children born, 3203 died under five years of age, and the remaining 6797 completed their fifth year. Also, that out of 6797 children who attained to five years of age, 6460 survived their tenth year.

But the mortality under ten years of age has been greatly reduced since then by the practice of vaccination.

This table also shows, that of 6460 individuals who attained to 10 years of age, 6047 survived 21; and that of 5075 who attained to 40, only 3643 survived their 60th year.

34. There is good reason to believe (as has been shown in another place) that the general law of mortality, that is, the average proportion of persons attaining to any one age, who survive any greater age, remains much the same now among the entire mass of the people throughout England, as it was found to be at Carlisle during the period of these observations, except among children under ten years of age, as was noticed above. (33.)

If this be so, it will follow, that of 6460 children now 10 years of age, just 6047 will attain to 21; or rather, that if any great number be taken in several instances, this $\left(\frac{6047}{6460}\right)$ will be the average proportion of them that will survive the period.

And if 6460 children were to be taken indiscriminately from the general mass of the population at 10 years of age, and an office or company were to engage to pay L.1 eleven years hence for each of them that might then be living, this engagement would be equivalent to that which should bind them to pay L.6047 certainly at the expiration of the term. Therefore the office, in order that it might neither gain nor lose by the engagement, should, upon entering into it, be paid for the whole, the present value of L.6047 to be received at the expiration of eleven years; and for each life the $\frac{1}{6460}$th part of it, that is, the $\frac{6047}{6460}$th part of the present value of L.1, to be received then.

But when the rate of interest is 5 *per cent.*, the present value of L.1, to be received at the expiration of 11 years, is L.0·584679; therefore, at that rate of interest, there should be paid for each life $\frac{6047 \times 0{\cdot}584679}{6460} = \text{L.}0{\cdot}5473$.

And the present value of L.100, to be received upon a life now 10 years of age attaining to 21, will be L.54·73, or L.54. 14s. 7d.

In the same manner it will be found, that reckoning interest at 4 *per cent.*, the value would be L.60. 16s. 1d.

35. This is the method of calculating the present values of endowments for children of given ages; and the values of annuities on lives may be computed in the same manner.

For, from the above reasoning it is manifest, that if the present value of L.1, to be received certainly at the expiration of a given term, be multiplied by the number in the table of mortality against the age, greater than that of any proposed life by the number of years in the term, and the product be divided by the number in the same table, against the present age of that life; the quotient will be the present value of L.1, to be received at the expiration of the term, provided that the life survive it.

And if, in this manner, the value be determined of L.1, to be received upon any proposed life, surviving each of the years in its greatest possible continuance, according to the table of mortality adapted to it; that is, according to the Carlisle table, upon its surviving every age greater than its present, to that of 104 years inclusive; then, the sum of all these values will evidently be the present value of an annuity on the proposed life.

36. If 5642 lives at 30 years of age be proposed, and 5075 at the age of 40; since each of the 5642 younger lives may be combined with every one of the 5075 that are 10 years older, the number of different pairs, or different combinations of two lives differing in age by 10 years, that may be formed out of the proposed lives, is 5642 times 5075.

But at the expiration of 15 years the survivors of the lives now 30 and 40 years of age, being then of the respective ages of 45 and 55, will be reduced to the numbers of 4727 and 4073 respectively; and the number of pairs, or combinations of two, differing in age by 10 years, that can be formed out of them, will be reduced from 5642×5075 to 4727×4073.

So that L.1 to be paid at the expiration of 15 years for each of these 5642×5075 pairs or combinations of two now existing, which may survive the term, will be of the same value in present money as 4727 times L.4073 to be received certainly at the same time.

Now, let A be any one of these lives of 30 years of age, and B any one of those aged 40; and, from what has been advanced, it will be evident that the present value of L.1, to be received upon the two lives in this particular combination jointly surviving the term, will be the same as that of the sum $\frac{\text{L.}4727 \times 4073}{5642 \times 5075}$ to be then received certainly.

But, when the rate of interest is 5 *per cent.*, L.1 to be received certainly at the expiration of 15 years, is equivalent to L.0·481017 in present money. (Table I.)

Therefore, at that rate of interest, and according to the Carlisle table of mortality, the present value of L.1 to be received upon A and B, now aged 30 and 40 years respectively, jointly surviving the term of 15 years, will be $\frac{4727 \times 4073 \times \text{L.}0{\cdot}481017}{5642 \times 5075}$.

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37. Hence it is sufficiently evident how the present value of L.1 to be received upon the same two lives jointly surviving any other year may be found. And if that value for each year from this time until the eldest life attain to the limit of the table of mortality be calculated, the sum of all these will be the present value of an annuity of L.1 dependent upon their joint continuance.

In this manner, it is obvious that the value of an annuity on the joint continuance of any other two lives might be determined.

38. If, besides the 5642 lives at 30 years of age, and the 5075 at 40 (mentioned in No. 36), there be also proposed 3643 at 60 years of age, each of these 3643 at 60 may be combined with every one of the 5642×5075 different combinations of a life of 30, with one of 40 years of age; and, therefore, out of these three classes of lives $5642 \times 5075 \times 3643$ different combinations may be formed, each containing a life of 30 years of age, another of 40, and a third of 60.

But at the expiration of 15 years the numbers of lives in these three classes will, according to the table of mortality, be reduced to 4727, 4073, and 1675 respectively; the respective ages of the survivors in the several classes being then 45, 55, and 75 years; and the number of different combinations of three lives (each of a different class from either of the other two) that can be formed out of them, will be reduced to $4727 \times 4073 \times 1675$.

Hence, by reasoning as in No. 36, it will be found, that if A, B, and C be three such lives, now aged 30, 40, and 60 years, the present value of L.1 to be received upon these three jointly surviving the term of 15 years from this time, will be $\frac{4727 \times 4073 \times 1675}{5642 \times 5075 \times 3643} \times$ L.0·481017 : interest being reckoned at 5 *per cent.*

Thus it is shown how the present value of an annuity dependent upon the joint continuance of these three lives might be calculated, that being the sum of the present values thus determined, of the rents for all the years which, according to the table of mortality, the eldest life can survive.

39. But it is easy to see that the same method of reasoning may be used in the case of four, five, or six lives, and so on without limit. Whence this inference is obvious.

The present value of L.1 to be received at the expiration of a given term, provided that any given number of lives all survive it, may be found by multiplying the present value of L.1 to be received certainly at the end of the term, by the continual product of the numbers in the table of mortality against the ages greater respectively by the number of years in the term than the ages of the lives proposed, and dividing the last result of these operations by the continual product of the numbers in the table of mortality against the present ages of the proposed lives.

And by a series of similar operations, the present value of an annuity on the joint continuance of all these lives might be determined.

But it should be observed, that, in calculating the value of a life-annuity in this way, the denominator of the fractions expressing the values of the several years' rents, that is, the divisor used in each of the operations, remains always the same: the division should, therefore, be left till the sum of the numerators is determined; and one operation of that kind will suffice.

40. Enough has been said to show that these methods of constructing tables of the values of annuities on lives are practicable, though excessively laborious; and, in fact, all the early tables of this kind were constructed in that manner. We proceed now to show how such tables may be calculated with much greater facility.

41. By the method of No. 34, it will be found that, reckoning interest at 5 *per cent.*, the present value of L.1 to be received at the expiration of a year, provided that a life, now 89 years of age, survived till then, is $\frac{142 \times 0{\cdot}95238}{181}$. But the age of that life will then be 90 years, and the proprietor of an annuity of L.1 now depending upon it will, in that event, receive his annual payment of L.1 then due; therefore, if the value then of all the subsequent payments, that is, the value of an annuity on a life of 90, be 2·339 years' purchase, the present value of what the title to this annuity may produce to the proprietor at the end of the year will be the same as that of L.3·339, to be received then, if the life be still subsisting, or $\frac{142 \times 0{\cdot}952381}{181} \times$ L.3·339 = L.2·495; which, therefore, will be the present value of an annuity of L.1 on a life of 89 years of age. That is to say, an annuity on that life will now be worth 2·495 years' purchase. (7.)

42. In the same manner it appears generally, that if unit be added to the number of years' purchase that an annuity on any life is worth, and the sum be multiplied by the present value of L.1 to be received at the end of a year, provided that a life one year younger survive till then, the product will be the number of years' purchase an annuity on that younger life is worth in present money.

43. But, according to the table of mortality, an annuity on the eldest life in it is worth nothing; therefore, the present value of L.1 to be received at the end of a year provided that the eldest life but one in the table survive till then, is the total present value of an annuity of L.1 on that life; which being obtained, the value of an annuity on a life one year younger than it may be found by the preceding number; and so on for every younger life successively.

EXEMPLIFICATION.

Rate of Interest 5 *per cent.*

Age of Life.	Value of an Annuity on that Life, increased by Unit,	Which being multiplied by 0·952381, and the Product by	Produces the value of an Annuity on the next younger Life,	Its Age being
104	1·000	$\frac{1}{3}$	0·317	103
103	1·317	$\frac{3}{5}$	0·753	102
102	1·753	$\frac{5}{7}$	1·192	101
101	2·192	$\frac{7}{9}$	1·624	100
100	2·624	$\frac{9}{11}$	2·045	99
99	3·045	$\frac{11}{14}$	2·278	98
98	3·278	$\frac{14}{18}$	2·428	97
97	3·428	$\frac{18}{23}$	2·555	96
96	3·555	$\frac{23}{30}$	2·596	95
95	3·596	$\frac{30}{40}$	2·569	94

44. Proceeding as in No. 36, it will be found that, at 5 *per cent.* interest, and according to the Carlisle table of mortality, the present value of L.1 to be received at the expiration of a year provided that a person now 89 years of age, and another now 99, be then living, is $\frac{142 \times 9 \times \text{L.}0{\cdot}952381}{181 \times 11}$; therefore, if the present value of an annuity of L.1 on the joint continuance of two lives, now aged 90 and 100 years respectively, be L.0·950, by reasoning as in No. 41, it will be found that the present value of an annuity on the joint continuance of two lives,

of the respective ages of 89 and 99 years, will be worth $\frac{142 \times 9 \times 0{\cdot}952381}{181 \times 11} \times 1{\cdot}950 = 1{\cdot}192$ years' purchase.

45. In this manner, commencing with the two oldest lives in the table that differ in age by ten years, and proceeding according to No. 43, the values of annuities on all the other combinations of two lives of the same difference of age may be determined.

The method is exemplified in the following specimen.

Ages of two Lives.	Value of an Annuity on their joint continuance, increased by Unit,	Which being multiplied by 0·952381, and the Product by	Produces the value of an Annuity on the two joint Lives one year younger respectively,	Their Ages being
94 & 104	1·000	$\frac{1 \times 40}{3 \times 54}$	0·235	93 & 103
93 & 103	1·235	$\frac{3 \times 54}{5 \times 75}$	0·508	92 & 102
92 & 102	1·508	$\frac{5 \times 75}{7 \times 105}$	0·733	91 & 101
91 & 101	1·733	$\frac{7 \times 105}{9 \times 142}$	0·950	90 & 100
90 & 100	1·950	$\frac{9 \times 142}{11 \times 181}$	1·192	89 & 99
89 & 99	2·192	$\frac{11 \times 181}{14 \times 232}$	1·280	88 & 98

46. Hence, and by what has been advanced in the 39th number of this article, it is sufficiently evident how a table may be computed of the values of annuities on the joint continuance of the lives in every combination of three, or any greater number; the differences between the ages of the lives in each combination remaining always the same in the same series of operations, while the calculation proceeds back from the combination in which the oldest life is the oldest in the table, to that in which the youngest is a child just born.

47. But when there are more than two lives in each combination, the calculations are so very laborious, on account principally of the great number of combinations, that no tables of that kind have yet been published, except three or four for three lives.

And in the books that contain tables of the values of two joint lives, methods are given of approximating towards the values of such combinations of two and of three lives as have not yet been calculated.

Therefore, assuming the values of annuities on single lives, and on the joint continuance of two or of three lives, to be given, we have next to show how the most useful problems respecting the values of any interests that depend upon the continuance or the failure of life may be resolved by them.

48. *Proposition* 1. The value of an annuity on the survivor of two lives, A and B, is equal to the excess of the sum of the values of annuities on the two single lives above the value of an annuity on their joint continuance.

49. *Demonstration.* If annuities on each of the two lives were granted to P, during their joint continuance he would have two annuities; but if P were only to receive these upon condition that, during the joint lives of A and B, he should pay one annuity to Q, then there would only remain one to be enjoyed by him or his heirs or assigns, until the lives both of A and B were extinct; whence the truth of the proposition is manifest.

50. *Prop.* 2. The value of an annuity on the joint continuance of the two last survivors out of three lives, A, B, and C, is equal to the excess of the sum of the values of annuities on the three combinations of two lives (A with B, A with C, and B with C) that can be formed out of them, above twice the value of an annuity on the joint continuance of all the three lives.

51. *Dem.* If one annuity were granted to P on the joint continuance of the two lives A and B, another on the joint continuance of A and C, and a third on the joint continuance of B and C; during the joint continuance of all the lives he would have three annuities.

But if he were only to receive these upon condition that he should pay two annuities to Q during the joint continuance of all the three lives, then there would only remain to himself one annuity during the joint existence of the last two survivors out of the three lives. And the truth of the proposition is manifest.

52. *Prop.* 3. The value of an annuity on the last survivor of three lives, A, B, and C, is equal to the excess of the sum of the values of annuities on each of the three single lives, together with the value of an annuity on the joint continuance of all the three, above the sum of the values of three other annuities; the first dependent upon the joint continuance of A and B, the second on that of A and C, and the third on B and C.

53. *Dem.* If annuities on each of the three single lives were granted to R, during the joint continuance of all the three he would have three annuities; and from the time of the extinction of the first life that failed, till the extinction of the second, he would have two.

So that he would have two annuities during the joint existence of the two last survivors out of the three lives; and besides these, a third annuity during the joint continuance of all the three.

Therefore, if out of these R were to pay one annuity to P during the joint continuance of the last two survivors out of the three lives, and another to Q during the joint continuance of all the three, he would only have left one annuity, which would be receivable during the life of the last survivor of the three.

But in the demonstration of the last proposition (51) it was shown, that the value of what he paid to P would fall short of the sum of the values of annuities dependent respectively on the joint continuance of A and B, of A and C, and of B and C, by two annuities on the joint continuance of all the three lives. Whence it is evident that the value of the annuities he paid both to P and Q would fall short of the sum of these three values of joint lives, only by the value of one annuity on the joint continuance of all the three lives.

Wherefore, if from the sum of the values of all the three single lives, the sum of the values of the three combinations of two that can be formed out of them were taken, there would remain less than the value of an annuity on the last survivor, by that of an annuity on the joint continuance of the three lives.

But if, to the sum of the values of the three single lives A, B, and C, there be added that of an annuity on the joint continuance of the three, and from the sum of these four values the sum of the values of the three combinations A with B, A with C, and B with C be subtracted, then the remainder will be the value of an annuity on the last survivor of the three lives; which was to be demonstrated.

54. *Prop.* 4. *Problem.* The law of mortality and the values of single lives at all ages being given, to determine the present value of an annuity on any proposed life, deferred for any assigned term.

55. *Solution.* Find the present value of an annuity on

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a life older than the proposed, by the number of years during which the other annuity is deferred; multiply this by the present value of L.1 to be received upon the proposed life surviving the term, and the product will be the value sought.

56. *Dem.* Upon the proposed life surviving the term, the annuity dependent upon it will be worth the same sum that an annuity on a life so much older is now worth; therefore it is evident that the deferred annuity is of the same present value as that sum to be received at the expiration of the term, provided the life survive it.

57. *Corollary.* In the same manner it appears, that the present value of an annuity on the joint continuance of any number of lives, deferred for a given term, may be found by multiplying the present value of an annuity on the joint continuance of the same number of lives, older respectively than the proposed by the number of years in the term, by the present value of L.1 to be received upon the proposed lives all surviving it.

58. A *temporary annuity* on any single life, or on the joint continuance of any number of lives, that is, an annuity which is to be paid during a certain term, provided that the single life or the other lives jointly subsist so long, together with an annuity on the same life or lives *deferred* for the same term, is evidently equivalent to an annuity on the whole duration of the same life or lives.

So that the value of an annuity on any life, or on the joint continuance of any number of lives, for an assigned term, is equal to the excess of the value of an annuity on their whole duration, with immediate possession, above the value of an annuity on them deferred for the term.

59. Whatever has been advanced from No. 48 to 53 inclusive, respecting the values of annuities for the whole duration of the lives whereon they depend, will apply equally to those which are either deferred or temporary; and therefore, to determine the value of any deferred or temporary annuity dependent upon the last survivor of two or of three lives, or upon the joint continuance of the last two survivors out of three lives, we have only to substitute temporary or deferred annuities, as the case may require, for annuities on the whole duration of the lives; and the result will accordingly be the value of a temporary or deferred annuity on the life of the last survivor, or on the joint lives of the two last survivors.

60. *Prop.* 5. *A* and *B* being any two proposed lives now in existence, the present value of an annuity to be payable only while *A* survives *B*, is equal to the excess of the value of an annuity on the life of *A* above that of an annuity on the joint existence of both the lives.

61. *Dem.* If an annuity on the life of *A*, and to be entered upon immediately, were now granted to *P* upon condition that he should pay it to *B* during the joint lives of *A* and *B*, it is evident that there would only remain to *P* an annuity on the life of *A* after the decease of *B*; whence the truth of the proposition is manifest.

62. When any thing is affirmed or demonstrated of *any life or lives*, it is to be understood as applying equally to any proposed single life, or to the joint continuance of the whole of any number of lives that may be proposed together, or to that of any assigned number of the last survivors of them, or to the last surviving life of the whole.

63. *Prop.* 6. The present value of the reversion of a perpetual annuity after the failure of any life or lives, is equal to the excess of the present value of the perpetuity, with immediate possession, above the present value of an annuity on the same life or lives.

64. *Dem.* If a perpetual annuity with immediate possession were granted to *P*, upon condition that he should pay the annual produce to another individual during the existence of the life or lives proposed, it is evident that there would only remain to *P* the reversion after the failure of such life or lives; and the present value of that reversion would manifestly be as stated above.

65. The 6th, 7th, and 8th tables at the end of this article, which have been extracted from the 19th, 21st, and 22d respectively, in Mr Milne's *Treatise on Annuities*, will serve to illustrate the application of these propositions to the solution of questions in numbers.

In all the following examples, we suppose the lives to be such as the general average of those from which the Carlisle table of mortality was constructed, and the rate of interest to be 5 *per cent.*

66. *Ex.* 1. What is the present value of an annuity on the joint lives, and the life of the survivor of two persons now aged 40 and 50 years respectively?

According to No. 48, the process is as follows:

Value of a single life of	40	13·390 (by Table VI.)
	50	11·660
	sum	25·050
Subtract the value of their joint lives,		9·984 (Table VIII.)
	remains	15·066 years' purchase, the required value.

And if the annuity be L.200, its present value will be L.3013·2, or L.3013. 4s.

67. *Ex.* 2. The lives *A*, *B*, and *C*, being now aged 50, 55, and 60 years respectively, an annuity on the joint continuance of all the three is worth 6·289 years' purchase, what is the value of an annuity on the joint existence of the last two survivors of them?

According to No. 50, the process is thus:

Ages.	Values.	
50 & 55	8·528	(Table VII.)
55 & 60	7·106	
50 & 60	7·601	(Table VIII.)
	sum 23·235	
Subtract 2 × 6·289 = 12·578		
	remains 10·657 years' purchase, the required value.	

Therefore, if the annuity were L.300, it would be worth L.3197. 2s. in present money.

68. *Ex.* 3. Required the value of an annuity on the last survivor of the three lives in the last example.

Proceeding according to No. 52, we have

Ages.	Values.	
50	11·660	(Table VI.)
55	10·347	
60	8·940	
50, 55, & 60	6·289	(No. 67).
	sum 37·236	
Subtract the sum of the values of annuities on the three combinations of two lives,	23·235	(No. 67.)
	remains 14·001 years' purchase, the required value.	

And if the annuity were L.300, it would now be worth L.4200. 6s.

69. *Ex.* 4. What is the present value of an annuity on a life now 45 years of age, which is not to be entered upon until the expiration of ten years; the first payment thereof being to be made at the expiration of eleven years from this time, if the life survive till then?

Solution.

The present value of an annuity on a life of 55 is 10·347 (Table VI.), and the present value of L.1 to be received upon the proposed life attaining to the age of 55, is $\frac{4073}{4727} \times 0{\cdot}613913$; therefore, by No. 55, the required value is $\frac{4073 \times 0{\cdot}613913 \times 10{\cdot}347}{4727} = 5{\cdot}473$ years' purchase; so that if the annuity were L.200, its present value would be L.1094. 12s.

70. *Ex.* 5. Required the present value of an annuity to be received for the next ten years, provided that a person now 45 years of age shall so long live.

Solution.

The present value of an annuity on a life of 45, to be entered upon immediately, is 12·648 (Table VI.)
Subtract that of an annuity on the same life deferred 10 years, } 5·473 (69.)

the remainder 7·175

is the required number of years' purchase. And if the annuity were L.200, its present value would be L.1435.

71. *Ex.* 6. An annuity on a life of 45, deferred 10 years, was shown in No. 69 to be worth 5·473 years' purchase in present money; let it be required to determine the equivalent annual payment for the same, to be made at the end of each of the next 10 years, but subject to failure upon the life failing in the term.

Solution.

The present value of L.1 *per annum* on the proposed life for the next 10 years has just been shown to be L.7·175, and this, multiplied by the required annual payment, must produce L.5·473; that payment must, therefore, be $\frac{5{\cdot}473}{7{\cdot}175} = 0{\cdot}76279$. And since the annual payment for the deferred annuity of L.1 *per annum* would be L.0·76279, that for an annuity of L.200 must be L.152. 11s. 2d.

72. *Ex.* 7. Let the present value be required of an annuity on a life now 40 years of age, to be payable only while that life survives another now of the age of 50 years.
From the present value of a life of 40, } 13·390 (Table VI.)
Subtract that of the two joint lives, } 9·984 (Table VIII.)

the remainder, 3·406

years' purchase, is the required value. (60.)

Therefore, if the annuity were L.100, it would be worth L.340. 12s. in present money.

73. If the annuity in the last example were to be paid for by a constant annual premium at the end of each year while both the lives survived; by reasoning as in No. 71, it will be found, that such annual premium for an annuity of L.1 should be $\frac{3{\cdot}406}{9{\cdot}984} = \text{L.}0{\cdot}341146$; for an annuity of L.100 it should therefore be L.34. 2s. 3½d.

74. But if one of the equal premiums for this annuity is to be paid down now, and another at the end of each year while both the lives survive, the number of years' purchase the whole of these premiums are worth will evidently be increased by unit; on account of the payment made now, it will therefore be 10·984; and each premium for an annuity of L.1 must, in this case, be $\frac{3{\cdot}406}{10{\cdot}984} = \text{L.}0{\cdot}310087$; for an annuity of L.100 it should therefore be L.31. 0s. 2d.

75. *Ex.* 8. Let it be required to determine the present value of the reversion of a perpetual annuity after the failure of a life now 50 years of age.

Solution.

The value of the perpetuity is 20 years' purchase. (8.)
Subtract that of an annuity on the life of 50, } 11·660 (Table VI.)

remains 8·34 years' purchase, the required value of the reversion. (63.)

So that if the annuity were L.300, its present value would be L.2502.

76. In the same manner it will be found, by the 68th number and those referred to in the last example, that the reversion of a perpetuity, after the failure of the last survivor of three lives, now aged 50, 55, and 60 years respectively, is worth 5·999 years' purchase in present money; therefore, if it were L.100 *per annum*, its present value would be L.599. 18s.

III.—Of Assurances on Lives.

77. An assurance upon a life or lives is a contract by which the office or underwriter, in consideration of a stipulated premium, engages to pay a certain sum upon such life or lives failing within the term for which the assurance is effected.

78. If the term of the assurance be the whole duration of the life or lives assured, the sum must necessarily be paid whenever the failure happens; and, in what follows, that payment is always supposed to be made at the end of the year in which the event assured against takes place; the anniversary of the assurance, or the day of the date of the policy, being accounted the beginning of each year.

79. At the end of the year in which any proposed life or lives may fail, the proprietor of the reversion of a perpetual annuity of L.1 after their failure will receive the pound then due, and will at the same time enter upon the perpetuity; therefore, the present value of the reversion is the same as that of L.1 added to the money a perpetual annuity of L.1 would cost, supposing this sum not to be receivable until the expiration of the year in which the failure of the life or lives might happen.

80. Hence we have this proportion. As the value of a perpetuity increased by unit is to L.1, so is the present value of the reversion of a perpetual annuity of L.1, after the failure of any life or lives, to the present value of L.1, receivable at the end of the year in which such failure shall take place.

81. Therefore, *if the value of an annuity of one pound on any life or lives be subtracted from that of the perpetuity, and the remainder be divided by the value of the perpetuity increased by unit, the quotient will be the value, in present money, of the assurance of one pound on the same life or lives.* (63.)

82. *Ex.* 1. What is the present value of L.1 to be received at the end of the year in which a life now 50 years of age may fail?

The rate of interest being 5 *per cent.*, the value of the perpetuity is 20 years' purchase, and that of the life 11·66; the answer therefore is $\frac{20-11{\cdot}66}{20+1} = \frac{8{\cdot}34}{21} = \text{L.}0{\cdot}397143$. And if the sum assured were L.1000, the present value of the assurance would be L.397. 2s. 10d.

83. When the term of a life-assurance exceeds one year, its whole value is hardly ever paid down at the time that the contract is entered into; but in the instrument (called a policy) whereby the assurance is effected, an equivalent annual premium is stipulated for, payable at the *commence-*

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ment of each year during the term, but subject to failure with the life or lives assured.

84. But by reasoning as in No. 74, it will be found that an annual premium, payable at the *commencement* of each year in the whole duration of the life or lives assured, will be worth one year's purchase more than an annuity on them payable at the *end* of each year; and, consequently, that if the value in present money of an assurance on any life or lives be divided by the number of years' purchase an annuity on the same life or lives is worth, increased by unit, the quotient will be the equivalent annual premium for the same assurance.

85. *Ex.* 2. Required the annual premium for the assurance of L.1 on a life of 50 years of age.

In No. 82 the single premium for that assurance was shown to be 0·397143, and the value of an annuity on the life is 11·66; therefore, by the preceding number, the required annual premium will be $\frac{0{\cdot}397143}{12{\cdot}66} = {\cdot}0313699$ for the assurance of L.1; and for the assurance of L.1000 it will be L.31. 7s. 5d.

86. *Ex.* 3. Let both the single payment in present money, and the equivalent annual premium, be required for the assurance of L.1, on the joint continuance of two lives of the respective ages of 45 and 50 years.

The value of an annuity of L.1 on the joint continuance of these two lives appears by Table VII. to be L.9·737, therefore $\frac{20-9{\cdot}737}{20+1} = \frac{10{\cdot}263}{21} =$ L.0·488714 is the single premium, and $\frac{0{\cdot}488714}{10{\cdot}737} =$ L.0·0455168 the equivalent annual one, for the assurance of L.1 to be paid at the end of the year in which that life becomes extinct which may happen to fail the first of the two.

Therefore, if the sum assured were L.500, the total present value of the assurance would be L.244. 7s. 2d., and the equivalent annual premium L.22. 15s. 2d.

87. *Ex.* 4. Let both the single and the equivalent annual premium be required for the assurance of L.1 on the life of the survivor of two persons now aged 40 and 50 years respectively.

The value of an annuity on the survivor of these two lives was shown in No. 66 to be 15·066, therefore, by No. 81, the single premium will be $\frac{20-15{\cdot}066}{20+1} = \frac{4{\cdot}934}{21}$ = L.0·234952; and, by No. 84, the annual one will be $\frac{\text{L.}0{\cdot}234952}{16{\cdot}066} =$ L.0·0146242.

That is, for the assurance of L.1 to be received at the end of the year in which the last surviving life of the two becomes extinct.

Therefore, for the assurance of L.5000, the single premium will be L.1174. 15s. 2d., the equivalent annual one L.73. 2s. 5d.

88. *Ex.* 5. What should the single and equivalent annual premiums be for an assurance on the last survivor of three lives of the respective ages of 50, 55, and 60 years?

The value of an annuity on the last survivor of them was shown in No. 68 to be 14·001, the single premium should therefore be $\frac{20-14{\cdot}001}{20+1} = \frac{5{\cdot}999}{21} =$ L.0·285666, and the annual $\frac{\text{L.}0{\cdot}285666}{15{\cdot}001} =$ L.0·0190431, for the assurance of L.1 to be received at the end of the year in which the last surviving life of the three may fail.

For the assurance of L.2000, the single premium would therefore be L.571. 6s. 8d., the annual one L.38. 1s. 9d.

89. *Lemma.* If an annuity be payable at the *commencement* of each year which some assigned life or lives may *enter upon* in a given term, the number of years' purchase in its present value will exceed by unit the number of years' purchase in the present value of an annuity on the same life or lives for one year less than the given term, but payable, as annuities generally are, at the *end* of each year.

Demonstration. Since the proposed life or lives can only enter upon any year after the first by surviving the year that precedes it, the receipt of each of the payments after the first, that are to be made at the commencement of the year, will take place at the same time and upon the same conditions as that of the rent for the year then expired of the life-annuity, for a term one year less than the term proposed: this last-mentioned annuity will therefore be worth, in present money, just the same number of years' purchase as all the payments subsequent to the first which may be made at the commencements of the several years.

And since the first of these is to be made immediately, the present value of the whole of them will evidently exceed the number of years' purchase last mentioned by unit; which was to be demonstrated.

90. If, while the rest remains the same, the payment of the annuity which depends upon the assigned life or lives *entering upon* any year is not to be made until the end of that year; as the condition upon which every payment is to be made will remain the same, but each of them will be one year later; the only alteration in the value of the whole will arise from this increase in the remoteness of payment, by which it will be reduced in the ratio of L.1 to the present value of L.1 receivable at the end of a year. (2.)

91. When the value of an annuity on any proposed life or lives for an assigned term is given, it is evident that the value of an annuity on the same life or lives for one year less may be found, by subtracting from the given value the present value of the rent to be received upon the proposed life or lives surviving the term assigned.

92. *Proposition.* The present value of an assurance on any proposed life or lives for a given term is equal to the excess of the value of an annuity to be paid at the end of each year which the life or lives proposed may *enter upon* in the term, above the value of an annuity on them for the same term, but dependent, as usual, upon their surviving each year.

Demonstration. If an annuity, payable at the end of each year which the proposed life or lives may enter upon during the given term, be granted to P upon condition that he shall pay over what he receives to Q at the end of each year which the same life or lives may survive, it is manifest that there will only remain to P the rent for the year in which the proposed life or lives may fail; that is, the assurance of that sum thereon for the given term (77); which was to be demonstrated.

93. From the last four numbers (89–92) we derive the following

RULE

for determining the present value of an assurance on any life or lives for a given term.

Add unit to the value of an annuity on the proposed life or lives for the given term, and from the sum subtract the present value of one pound to be received upon the same life or lives surviving the term; multiply the remainder by the present value of L.1 *to be received certainly at the end of a year, and from the product subtract the present value of an annuity on the proposed life or lives for the term.*

This last remainder will be the value in present money

of the assurance of L.1 during the same term on the life or lives proposed.

94. It has been shown above (34–39) how the present value of L.1 receivable upon any single or joint lives surviving an assigned term may be found. And all that was demonstrated from No. 48 to 53 inclusive, respecting annuities on the last survivor of two or of three lives, or on the joint continuance of the two last survivors out of three lives, is equally true of any particular year's rent of those annuities. Hence it is evident how the present value of L.1, to be received upon the last survivor of two or of three lives, or upon the last two survivors out of three lives, surviving any assigned term, may be found.

95. *Example.* Required the present value of L.1, to be received at the end of the year in which a life now forty-five years of age may fail, provided that such failure happen before the expiration of ten years.

Here the present value of L.1, to be received on the life surviving the term, will be found to be L.0·528976, and the value of an annuity on the proposed life for the term is 7·175. (70.)

From 8·175
subtract 0·528976

the remainder 7·646024
being multiplied by 0·952381

produces 7·28193
from this subtract 7·17500

remains L.0·10693, the required value of the assurance; and if the sum assured were L.3000, the value of the assurance in present money would be L.320. 15s. 7d.

96. By numbers 89, 91, and 95, it appears that an annuity, payable at the commencement of each of the next ten years that a life of 45 enters upon, is worth 7·646 years' purchase; therefore, $\frac{0\cdot10693}{7\cdot646}$ = L.0·013985 will be the annual premium for the assurance of L.1 for ten years on that life. For the assurance of L.3000, it will therefore be L.41. 19s. 1d.

97. When the term of the assurance is the whole duration of the life or lives assured, L.1 to be received upon their surviving the term is worth nothing; and an annuity on the lives for the term is also for their whole duration.

Therefore from No. 93 we derive the following

RULE

for determining the present value of an assurance on any life or lives.

Add unit to the value of an annuity on the proposed life or lives; multiply the sum by the present value of L.1 *to be received certainly at the end of a year, and from the product subtract the value of an annuity on the same life or lives.*

The remainder will be the value of the assurance in present money.

98. *Example.* Required the present value of L.1 to be received at the end of the year in which the survivor of two lives may fail, their ages now being 40 and 50 years respectively.

The value of an annuity on these lives was shown in No. 66 to be 15·066.

Multiply 16·066 by 0·952381, from the product 15·3009 subtract 15·066, the remainder L.0·2349 is the required value, agreeably to No. 87.

And, in all other cases, the values determined by the rule in the preceding number will be found to agree with those obtained by the method of No. 81.

99. When an assurance on any life or lives has been effected at a constant annual premium, and kept up for some time by the regular payment of that premium, the annual premium required for a new assurance of the same sum on the same life or lives will, on account of the increase of age, be greater than that at which the first assurance was effected: Therefore the present value of all these greater annual premiums, that is, the total present value of the new assurance, will exceed the present value of all the premiums that may hereafter be received under the existing policy. And the excess will evidently be the value of the policy, supposing the life or lives to be still insurable; that being the only advantage which can now be derived from the premiums already paid.

So that if the present value of all the future annual premiums to be paid under an existing policy, for the assurance of a certain sum upon any life or lives, be subtracted from the present value of the assurance of the same sum on the same life or lives, the remainder will be the value of the policy.

100. *Example.* L.1000 has been assured some years on a life now 50 years of age, for its whole duration, at the annual premium of L.20, one of which has just now been paid. What is the value of the policy?

The present value of the assurance of L.1000 on that life has been shown in No. 82 to be L.397. 2s. 10d.; and an annuity on the life being worth 11·66 years' purchase (Table VI.), the present value of all the premiums to be paid in future under the existing policy is 11·66 × L.20 = L.233. 4s.; the value of the policy, therefore, is L.163. 18s. 10d.

Immediately before the payment of the premium the value of the policy would evidently have been less by the premium then due.

101. In our investigations of the values of annuities on lives, we have hitherto assumed that no part of the rent is to be received for the year in which the life wherewith the annuity may terminate fails.

But if a part of the annuity is to be received at the end of that year, proportional to the part of the year which may have elapsed at the time of such failure; as, in a great number of such cases, some of the lives wherewith the annuity terminates will fail in every part of the year, and as many, or very nearly so, in any one part of it as in any other: we may assume that, upon an average, half a year's rent will be received at the end of the year in which such failure happens; and therefore, that by the title to what may be received after the failure of the life or lives whereon the annuity depends, the present value of that annuity will be increased by the present value of the assurance of half a year's rent on the same life or lives.

102. Thus, for example, the present value of the assurance of L.1 on a life of 50 years of age having in No. 82 been shown to be L.0·397143, the value of an annuity of L.1 on that life, when payable till the last moment of its existence, will exceed L.11·66, its value if only payable until the expiration of the last year it survives, by $\left(\frac{\text{L.}0\cdot397143}{2} =\right)$ L.0·199; it will therefore be L.11·859.

103. If at the end of the year in which an assigned life *A* may fail, *Q* or his heirs are to receive L.1, and are at the same time to enter upon an annuity of L.1, to be enjoyed during another life *P*, to be then fixed upon; the present value of *Q's* interest will evidently be the same as that of the assurance on the life of *A*, of a number of pounds, exceeding by unit the number of years' purchase in the value of an annuity on the life of *P*, at the time of nomination.

104. What is the present value of the next presentation to a living of the clear annual value of L.500, *A*, the present incumbent, being now 50 years of age; supposing

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the age of the clerk presented to be 25 at the end of the year in which the present incumbent dies; also, that he takes the whole produce of the living for that year?

By Table VI. it will be found that the value of an annuity of L.1 on a life of 25 is L.15·303; and in No. 82 it has been shown, that the present value of the assurance of L.1 on a life of 50 is L.0·397143. Hence, and by the last number, it appears that if the annual produce of the living were but L.1, the present value of the next presentation would be L.16·303 × 0·397143 = L.6·47467. The required value, therefore, is L.3237. 6s. 9d.

105. If to the value of the succeeding life, determined according to No. 103, the value of the present be added, the sum of these will evidently be the present value of both the lives in succession; and, in the case of the preceding number, will be 6·475 + 11·66 = 18·135 years' purchase.

106. In No. 103 we proceeded upon the supposition that the annuity on the present life is only payable up to the expiration of the last year it survives, and, consequently, that the succeeding life takes the whole rent for the year in which the present fails.

But if the succeeding life is only to take a part of that rent, in the same proportion to the whole as the portion of the year which intervenes between the failure of the present life and the end of the year is to the whole year, then, by reasoning as in No. 101, it will be found that the portion of that rent which the succeeding life will receive may be properly assumed to be one half. And, instead of increasing the number of years' purchase the annuity on the succeeding life will be worth at the end of the year in which the other fails by unit, we must only add one half to that number, in order that the present value of the assurance of the sum on the existing life may be the number of years' purchase which all that may be received during the succeeding life is now worth.

107. The value of the succeeding life, in the case of No. 104, will, upon this hypothesis, be 15·803 × 0·397143 = 6·27605 years' purchase.

And this appears to be the most correct way of calculating the value of an annuity on a succeeding life, although that of No. 103 proceeds upon the principle on which life-interests are generally valued.

108. But the value of two lives in succession will be the same on both hypotheses; the rent for the year in which the first may fail being, in the one case, given entirely to the successor; and, in the other, divided equally between the two.

This is also true of any greater number of successive lives.

PART II.

109. We now proceed to treat the subject of annuities *Algebraically*.

I.—On Annuities-Certain.

Let r denote the *simple interest* of L.1 for one year.
s, any *sum* put out at interest.
n, the *number of years* for which it is lent.
m, its *amount* in that time.
a, an *annuity* for the same time. (3 and 4.)
M, the *amount* to which that *annuity* will increase when each payment is laid up as it becomes due, and improved at compound interest until the end of the term.
V, the *present value* of the same annuity. (6.)

110. Then, reasoning as in the first number of this article, it will be found that $m = s(1+r)^n$. And by No. 2 it appears that the present value of s pounds to be received certainly at the expiration of n years, is $s\frac{1}{(1+r)^n}$, or $s(1+r)^{-n}$.

111. The amount of L.1 in n years being $(1+r)^n$, its increase in that time will be $(1+r)^n - 1$; and when it is considered that this increase arises entirely from the simple interest (r) of L.1 being laid up at the end of each year, and improved at compound interest during the remainder of the term, it must be obvious that $(1+r)^n - 1$ is the amount of an annuity of r pounds in that time; but $r : a :: (1+r)^n - 1 : \frac{a}{r}\left[(1+r)^n - 1,\right]$ which, therefore, is equal to M, the amount of an annuity of a pounds in n years.

112. Reasoning as in No. 8, it will be found, that since $r : 1 :: a : \frac{a}{r}$, the present value of a perpetual annuity of a pounds is $\frac{a}{r}$.

113. If two persons, A and B, purchase a perpetuity of a pounds between them, which A and his heirs or assigns are to enjoy during the first n years, and B and his heirs or assigns for ever after. Since the value of the perpetuity to be entered upon immediately has just been shown to be $\frac{a}{r}$, the present value of B's share, that is, the present value of the same perpetuity when the entrance thereon is deferred until the expiration n years, will be $\frac{a}{r}(r+1)^{-n}$, (110); and the value of the share of A will be thus much less than that of the whole perpetuity (21), therefore equal to $\frac{a}{r}\left[1-(1+r)^{-n}\right] =$ V, the present value of an annuity of a pounds for the term of n years certain.

114. If the annuity is not to be entered upon until the expiration of d years, but is then to continue n years, its value at the time of entering upon it will be $\frac{r}{a}\left[1-(1+r)^{-n}\right]$, as has just been shown; therefore its present value will be

$$\frac{a}{r}\left[(1+r)^{-d} - (1+r)^{-(d+n)}\right] = \text{V}. \quad (110.)$$

115. In the same manner it appears that, when the entrance on a perpetuity of a pounds is deferred d years, its present value will be $\frac{a}{r}(1+r)^{-d}$. (110 and 112.)

116. q being any number whatever, whole, fractional, or mixed, let λq denote its logarithm, and $\varkappa q$ the arithmetical complement of that logarithm; so that these equations may obtain, $\lambda\frac{1}{q} = -\lambda q = \varkappa q$. Then, for the resolution of the principal questions of this kind by logarithms, we shall have these formulæ.

1. *Amount of a sum improved at interest.*

$$\lambda m = n\lambda(1+r) + \lambda s. \quad (110.)$$

2. *Amount of an annuity when each payment is laid up as it becomes due, and improved at interest until the expiration of the term.*

$$\lambda M = \lambda\left[(1+r)^n - 1\right] + \lambda a + xr. \quad (111.)$$

3. *Value of a lease or an annuity.*

$$\lambda V = \lambda\left[1-(1+r)^{-n}\right] + \lambda a + xr. \quad (113.)$$

4. *Value of a deferred annuity, or the renewal of any number of years lapsed in the term of a lease.*

$$\lambda V = \lambda\left[(1+r)^{-d} - (1+r)^{-(d+n)}\right] + \lambda a + xr. \quad (114.)$$

5. *Value of a deferred perpetuity, or the reversion of an estate in fee-simple, after an assigned term.*

$$\lambda V = \lambda a + xr + dx(1+r). \quad (115.)$$

By means of each of these equations, it is manifest that any one of the quantities involved in it may be found when the rest are given.

117. If the interest be convertible into principal ν times in the year, at ν equal intervals; since the interest of L.1 for one of these intervals will be $\frac{r}{\nu}$ (109), and the number of conversions of interest into principal in n years νn; to adapt the formula in No. 110 to this case, we have only to substitute $\frac{r}{\nu}$ for r, and νn for n, in the equation $m = s(1+r)^n$ there given, whereby it will be transformed to this, $m = s\left(1+\frac{r}{\nu}\right)^{\nu n}$.

118. According as ν is equal to 1, 2, 4, or is infinite, that is, according as the interest is convertible into principal yearly, half-yearly, quarterly, or continually, let m be equal to Y, H, Q, or C; so shall

$$Y = s(1+r)^n,$$

$$H = s\left(1+\frac{r}{2}\right)^{2n},$$

$$Q = s\left(1+\frac{r}{4}\right)^{4n},$$

$$\text{and } C = s \cdot N;$$

N being the number of which nr is the hyperbolic logarithm, and $nr \times 0{\cdot}43429448$ its logarithm in Briggs' *System*, and the common tables.

119. From No. 117 and 110, it follows that the present value of s pounds to be received at the end of n years, when the interest is convertible into principal at ν equal intervals in each year, is $s\left(1+\frac{r}{\nu}\right)^{-\nu n}$.

120. When the present values and the amounts of annuities are desired, let the interest be convertible into principal at ν equal intervals in the year, while the annuity is payable at π intervals therein, the amount of each payment being $\frac{a}{\pi}$.

121. *Case* 1. μ being any whole number not greater than ν, let $\frac{1}{\pi} = \frac{\mu}{\nu}$, so that the interest may be convertible into principal μ times in each of the intervals between the payments of the annuity.

Then will the amount of L.1 at the expiration of the period $\frac{1}{\pi}$ be $\left(1+\frac{r}{\nu}\right)^{\mu}$ (117), and the interest of L.1 for the same time will be $\left(1+\frac{r}{\nu}\right)^{\mu} - 1$; whence the present value of the perpetuity will be $\dfrac{\frac{1}{\pi}a}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}$ (8), and the value of the same deferred n years, will be $\frac{a}{\pi} \cdot \dfrac{\left(1+\frac{r}{\nu}\right)^{-m}}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}$ (119), therefore the present value of the annuity to be entered upon immediately, and to continue n years, will be

$$\frac{a}{\pi} \cdot \frac{1-\left(1+\frac{r}{\nu}\right)^{-\nu n}}{\left(1+\frac{r}{\nu}\right)^{\mu}-1} = V.$$

122. *Case* 2. μ being any whole number greater than π, let $\frac{1}{\nu} = \frac{\mu}{\pi}$, so that the annuity may be payable μ times in each of the intervals between the payments of interest, or the conversion thereof into principal.

Then, at the expiration of the $\frac{1}{\nu}$th of a year, when the interest on the purchase-money is first payable or controvertible, the interest on all the $\mu - 1$ payments of the annuity previously made will be

$$\frac{ar}{\pi\pi}\left[(\mu-1)+(\mu-2)+(\mu-3)+\ldots\ldots+3+2+1\right]$$

$= \frac{a}{\pi} \cdot \frac{r\mu(\mu-1)}{2\pi}$; to which adding the μ payments of $\frac{a}{\pi}$ each (including the one only then due), the sum $\frac{a}{\pi}\left[\mu + \frac{r\mu(\mu-1)}{2\pi}\right]$, is the simple interest which the value of the perpetuity should yield at the expiration of each νth part of a year, in order to supply the deficiency (both of principal and interest) that would be occasioned during each of those periods, in any fund out of which the several payments of the annuity might be taken, as they respectively became due; and since $\frac{r}{\nu} : \frac{a}{\pi}\left[\mu + \frac{r\mu(\mu-1)}{2\pi}\right]$ $:: 1 : \frac{a\nu}{r\pi}\left[\mu + \frac{r\mu(\mu-1)}{2\pi}\right] = a\left(\frac{1}{r} + \frac{\mu-1}{2\pi}\right)$, this last expression will be the value of such perpetuity with immediate possession (8); the value of the same deferred n years will therefore be $a\left(\frac{1}{r} + \frac{\mu-1}{2\pi}\right) \times \left(1+\frac{r}{\nu}\right)^{-\nu n}$ (119). Whence it appears that the present value of the annuity to be entered upon immediately, and to continue n years, will be $a\left(\frac{1}{r} + \frac{\mu-1}{2\pi}\right) \cdot \left[1-(1+\frac{r}{\nu})^{-\nu n}\right] = V$.

123. *Case* 3. When, in consequence of the annuity being always payable at the same time that the interest is convertible, $\nu = \pi$.

Since the interest of L.1 at the expiration of the period $\frac{1}{\pi}$ will be $\frac{r}{\pi}$, the value of the perpetuity will be $\dfrac{\frac{1}{\pi}a}{\frac{1}{\pi}r} = \frac{a}{r}$ (8), whence, proceeding as before, we obtain the present value of the annuity, $\frac{a}{r}\left[1-(1+\frac{r}{\nu})^{-\nu n}\right] = V$. Whence $\nu = \pi$, and consequently $\mu = 1$, the values of V given in the two preceding cases, will be found to coincide with this.

124. According as ν and π are each equal to 1, 2, 4, or are infinite; that is, according as the interest and the annuity are each payable yearly, half-yearly, quarterly, or continually, let V be equal to y, h, q, or c, then will

$$y = \frac{a}{r}\left[1-(1+r)^{-n}\right],$$

$$h=\frac{a}{r}\left[1-\left(1+\frac{r}{2}\right)^{-2n}\right]$$

$$q=\frac{a}{r}\left[1-\left(1+\frac{r}{4}\right)^{-4n}\right],$$

and $c=\frac{a}{r}\left[1-\frac{1}{\text{N}}\right]$, N being as in No. 118.

125. The amount of an annuity is equal to the sum to which the purchase-money would amount if it were put out and improved at interest during the whole term.

For, from the time of the purchase of the annuity, whatever part of the money that was paid for it may be in the hands of the granter, he must improve thus to provide for the payments thereof; and if the purchaser also improve in the same manner all he receives, the original purchase-money must evidently receive the same improvement during the term, as if it had been laid up at interest at its commencement.

126. The periods of conversion of interest into principal, and of the payment of the annuity being still designated as in No. 120; since in n years the number of periods of conversion will be vn, in the

1st Case, where the interest is convertible μ times in each of the intervals between the payments of the annuity, we have $\left(1+\frac{r}{\nu}\right)^{vn}\text{v}=\frac{a}{\pi}\cdot\frac{\left(1+\frac{r}{\nu}\right)^{vn}-1}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}=\text{M}$. (117, 121, and 125.) In the *2d Case*, when the annuity is payable μ times, in each interval between the conversions of interest,

$$\left(1+\frac{r}{\nu}\right)^{vn}\text{v}=a\left[\frac{1}{r}+\frac{\mu-1}{2\pi}\right]\cdot\left[\left(1+\frac{r}{\nu}\right)^{vn}-1\right]$$

$=\text{M}$. (117, 122, and 125.)

And, in the *3d Case*, when the annuity is always payable at the same time that the interest is convertible, $\left(1+\frac{r}{\nu}\right)^{vn}\text{v}=\frac{a}{r}\left[\left(1+\frac{r}{\nu}\right)^{vn}-1\right]=\text{M}$. (117, 123, and 125.)

127. According as ν and π are each equal to 1, 2, 4, or are infinite; that is, according as the interest and the annuity are each payable yearly, half-yearly, quarterly, or continually, let M be denoted by y', h', q', or c';

then will
$$y'=\frac{a}{r}\left[(1+r)^{n}-1\right],$$
$$h'=\frac{a}{r}\left[\left(1+\frac{r}{2}\right)^{2n}-1\right],$$
$$q'=\frac{a}{r}\left[\left(1+\frac{r}{4}\right)^{4n}-1\right],$$

and $c=\frac{a}{r}(\text{N}-1)$; N being as in No. 118.

128. *Example* 1. What will L.320 amount to, when improved at compound interest during 40 years, the rate of interest being 4 *per cent. per annum?*

By the first formula in No. 116, the operation will be as follows:

$$1\times r=1{\cdot}04\ \lambda\ 0{\cdot}01703334$$
$$+\ n=40$$
$$(1+r)^{n}\ \lambda\ 0{\cdot}6813336$$
$$s=320\ \lambda\ 2{\cdot}5051500$$
$$m=1536{\cdot}327\ \lambda\ 3.1864836$$

And the answer is L.1536. 6s. 6½d.

129. *Ex.* 2. If the interest were convertible into principal every half-year, the operation, according to No. 117, would be thus:

$$1+\frac{r}{2}=1{\cdot}02\ \lambda\ 0{\cdot}00860017$$
$$\times\ vn=80$$
$$0{\cdot}6880136$$
$$s=320\ \lambda\ 2{\cdot}5051500$$
$$m=1560{\cdot}14\ \lambda\ 3{\cdot}1931636$$

So that in this case the amount would be L.1560. 2s. 9½d.

130. *Ex.* 3. Required the present value of an annuity of L.250 for 30 years, reckoning interest at 5 *per cent.*

By the third formula in No. 116, the operation will be thus:

$$\lambda\,(1+r)^{-1}=\varkappa\,1{\cdot}05=\bar{1}{\cdot}9788107$$
$$\times n=30$$
$$(1+r)^{-n}=\cdot23137704\ \lambda\ \bar{1}{\cdot}3643210$$
$$1-(1+r)^{-n}=\cdot76862296\ \lambda\ \bar{1}{\cdot}8857133$$
$$a=250\ \lambda\ 2{\cdot}3979400$$
$$r=\cdot05\ \varkappa\ 1{\cdot}3010300$$
$$\text{v}=3843{\cdot}114\ \lambda\ 3{\cdot}5846833$$

And the required value is L.3843. 2s. 3¼d.

131. *Ex.* 4. The rest being still the same, if the annuity in the last example be payable half-yearly, in the formula of No. 122 ν will be equal to 1, $\pi=2$, and $\mu=2$; that formula will therefore become $a\left(\frac{1}{r}+\frac{1}{4}\right)\cdot\left[1-(1+r)^{-n}\right]=\text{v}$; and the operation will be thus:

$$\left.\begin{array}{r}1-(1+r)^{-n}\ \lambda\ \bar{1}{\cdot}8857133\\ a=250\ \lambda\ 2{\cdot}3979400\end{array}\right\}\ \text{No. 130.}$$
$$\frac{1}{r}+\frac{1}{4}=20{\cdot}25\ \lambda\ 1{\cdot}3064250$$
$$\text{v}=3891{\cdot}15\ \lambda\ 3{\cdot}5900783$$

The value of the annuity will therefore in this case be L.3891. 3s.

132. *Ex.* 5. To what sum will an annuity of L.120 for 20 years amount, when each payment is improved at compound interest from the time of its becoming due until the expiration of the term, the rate of interest being 6 *per cent.?*

The operation by the second formula in No. 116 is thus:

$$1+r=1{\cdot}06\ \lambda\ 0{\cdot}025305865$$
$$\times\ n=20$$
$$(1+r)^{n}=3{\cdot}207135\ \lambda\ 0{\cdot}5061173$$
$$(1+r)^{n}-1=2{\cdot}207135\ \lambda\ 0{\cdot}3438289$$
$$a=120\ \lambda\ 2{\cdot}0791812$$
$$r=\cdot06\ \varkappa\ 1{\cdot}2218487$$
$$\text{M}=4414{\cdot}27\ \lambda\ 3{\cdot}6448588$$

And the amount required is L.4414. 5s. 5d.

133. *Ex.* 6. The rest being the same as in the last example; if both the interest and the annuity be payable half-yearly, the amount will be determined by the second of the formulæ given in No. 127, which in this case will become $\frac{120}{\cdot06}\left[(1{\cdot}03)^{40}-1\right]$, and the operation will be as follows:

$$1{\cdot}03\ \lambda\ 0{\cdot}01283723$$
$$\times\ 40$$
$$(1{\cdot}03)^{40}=3{\cdot}26204\ \lambda\ 0{\cdot}5134892$$
$$(1{\cdot}03)^{40}-1=2{\cdot}26204\ \lambda\ 0{\cdot}3545003$$
$$\lambda\ 2{\cdot}0791812$$
$$\cdot06\ \varkappa\ 1{\cdot}2218487$$
$$\text{M}=4524{\cdot}08\ \lambda\ 3{\cdot}6555302$$

So that the amount in this case would be L.4524. 1s. 7¼d.

II.—On the Probabilities of Life.

134. Any persons, A, B, C, &c. being proposed, let the numbers which tables of mortality (32) adapted to them represent to attain to their respective ages be denoted by the symbols a, b, c, &c.; while lives n years older than those respectively are denoted thus, ${}^nA$, ${}^nB$, ${}^nC$, &c. and the numbers that attain to their ages, by the symbols ${}^na$, ${}^nb$, ${}^nc$, &c.; also let lives n years younger than A, B, C, &c. be denoted thus, A_n, B_n, C_n, &c., while the numbers which the tables show to attain to those younger ages are designated by the symbols a_n, b_n, c_n, &c.

Then, if A be 21 years of age, and we use the Carlisle table, we shall have $a = 6047$, and ${}^{14}a = 5362$, the number that attain to the age of 35, or that live to be 14 years older than A.

Hence the number that are represented by the table to die in n years from the age of A will be $a - {}^na$, that is, in 14 years, $a - {}^{14}a$; and, by the Carlisle table, in 14 years from the age of 21, that is, between 21 and 35, it will be $6047 - 5362 = 685$.

135. *Problem.* To determine the probability that a proposed life A will survive n years.

Solution. a being the number of lives in the table of mortality attaining the age of that which is proposed, conceive that number of lives to be so selected (of which A must be one), that they may each have the same prospect with regard to longevity as the proposed life and those in the table, or the average of those from which it was constructed; then will the number of them that survive the term be ${}^na$. (134.)

So that the number of ways all equally probable, or the number of equal chances for the happening of the event in question, is ${}^na$; and the whole number for its either happening or failing is a; therefore, according to the first principles of the doctrine of probabilities, the probability of the event happening, that is, of A surviving the term, is $\frac{{}^na}{a}$.

If the age of A be 14, the probability of that life surviving 7 years, or the age of 21, will, according to the Carlisle table, be $\frac{{}^7a}{a} = \frac{6047}{6335}$, or 0·95454.

136. Since the number that die in n years from the age of A is $a - {}^na$ (134), it appears, in the same manner, that the probability of that life failing in n years will be $\frac{a - {}^na}{a} = 1 - \frac{{}^na}{a}$; which probability, when the life, term, and table of mortality are the same as in the last No., will be 0·04546.

137. If two lives A and B be proposed, since the probability of A surviving n years will be $\frac{{}^na}{a}$, and that of B surviving the same term will be $\frac{{}^nb}{b}$, it appears from the doctrine of probabilities that $\frac{{}^na}{a} \cdot \frac{{}^nb}{b}$ or $\frac{{}^n(ab)}{ab}$ will be the measure of the probability that these lives will both survive n years.

In the same manner it may be shown, that the probability of the three lives A, B, and C all surviving n years, will be measured by $\frac{{}^na}{a} \cdot \frac{{}^nb}{b} \cdot \frac{{}^nc}{c}$, or $\frac{{}^n(abc)}{abc}$. And, universally, that any number of lives A, B, C, &c. will jointly survive n years, the probability is $\frac{{}^n(abc, \&c.)}{abc, \&c.}$

138. Let $\frac{{}^na}{a} = {}_na$, $\frac{{}^nb}{b} = {}_nb$, $\frac{{}^nc}{c} = {}_nc$, &c.; also let $\frac{{}^n(abc, \&c.)}{abc, \&c.} = {}_n(abc, \&c.)$; so that the probabilities of A, B, C, &c. surviving n years may be denoted by ${}_na$, ${}_nb$, ${}_nc$, &c. respectively; and that of all these lives jointly surviving that term by ${}_n(abc, \&c.)$

Then will the probability that none of these lives will survive n years be $(1 - {}_na) \cdot (1 - {}_nb) \cdot (1 - {}_nc) \cdot$ &c.

139. But the probability that some one or more of these lives will survive n years will be just what the probability last mentioned is deficient of certainty: its measure, therefore, being just what the measure of that probability is deficient of unit, will be

$$1 - (1 - {}_na) \cdot (1 - {}_nb) \cdot (1 - {}_nc) \cdot \&c.$$

140. *Corol.* 1. When there is only one life A, this will be ${}_na$.

141. *Corol.* 2. When there are two lives A and B, it becomes ${}_na + {}_nb - {}_n(ab)$.

142. *Corol.* 3. When there are three lives A, B, and C, it becomes ${}_na + {}_nb + {}_nc - {}_n(ab) - {}_n(ac) - {}_n(bc) + {}_n(abc)$.

143. When three lives A, B, and C are proposed, that at the expiration of n years there will be

living	dead	the probability is
ABC	none	..... $+ {}_n(abc)$
AB	C	${}_n(ab) \cdot (1 - {}_nc) = {}_n(ab) - {}_n(abc)$
AC	B	${}_n(ac) \cdot (1 - {}_nb) = {}_n(ac) - {}_n(abc)$
BC	A	${}_n(bc) \cdot (1 - {}_na) = {}_n(bc) - {}_n(abc)$

And the sum of these four ${}_n(ab) + {}_n(ac) + {}_n(bc) - 2{}_n(abc)$, is the measure of the probability that some two at the least out of these three lives will survive the term.

III.—Of Annuities on Lives.

144. Let the number of years' purchase that an annuity on the life of A is worth, that is, the present value of L.1 to be received at the end of every year during the continuance of that life, be denoted by A; while the present value of an annuity on any number of joint lives A, B, C, &c. that is, of an annuity which is to continue during the joint existence of all the lives, but to cease with the first that fails, is denoted by ABC, &c.

Then will the value of an annuity on the joint continuance of the three lives A, B, and C, be denoted by ABC.

And on the joint continuance of the two A and B, by AB.

145. Also let ${}^tA$ and A_t denote the values of annuities on lives respectively older and younger than A, by t years; while ${}^t(ABC, \&c.)$ designates the value of an annuity on the joint continuance of lives t years older than A, B, C, &c. respectively; and $(ABC, \&c.)_t$ that of an annuity on the same number of joint lives, as many years younger than these respectively.

146. Let $\frac{1}{1+r}$, the present value of L.1 to be received certainly at the expiration of a year, be denoted by v.

Then will v^n be the present value of that sum certain to be received at the expiration of n years.

But if its receipt at the end of that time be dependent upon an assigned life A surviving the term, its present value will, by that condition, be reduced in the ratio of certainty to the probability of A surviving the term, that is, in the ratio of unit to ${}_na$, and will therefore be ${}_nav^n$.

In the same manner it appears, that if the receipt of the money at the expiration of the term be dependent upon any assigned lives, as A, B, C, &c. jointly surviving that period, its present value will be ${}_n(abc, \&c.)v^n$.

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147. Let us denote the sum of any series, as ${}_1(abc)v + {}_2(abc)v^2 + {}_3(abc)v^3 +$ &c. thus, $S_n(abc)v^n$, by prefixing the Italic capital S to the general term thereof. Then, from what has just been advanced, it will be evident that ABC, &c. $= S_n(abc, \&c.)v^n$.

When there are but three lives, A, B, and C, this becomes ABC $= S_n(abc)v^n$.

When there are but two, A and B, it becomes AB $= S_n(ab)v^n$.

And in the same manner it appears, that for a single life A, A $= S_n av^n$.

148. ${}_n(abc, \&c.)v^n = \frac{{}^n(abc, \&c.)v^n}{abc, \&c.}$ (138), where the denominator $(abc, \&c.)$ is constant, while the numerator varies with the variable exponent n. And the most obvious method of finding the value of an annuity on any assigned single or joint lives, is to calculate the numerical value of the term ${}^n(abc, \&c.)v^n$ for each value of n, and then to divide the sum of all these values by abc, &c.; for $\frac{S^n(abc, \&c.)v^n}{abc, \&c.}$ $= S_n(abc, \&c.)v^n =$ ABC, &c.

In calculating a table of the values of annuities on lives in that manner, for every combination of joint lives it would be necessary to calculate the term ${}^n(abc, \&c.)v^n$ for as many years as there might be between the age of the oldest life involved and the oldest in the table; and the same number of the terms ${}^n av^n$ for any single life of the same age.

But this labour may be greatly abridged as follows:

PROB. I.

149. Given $'$(ABC, &c.), the value of an annuity on any number of joint lives, to determine ABC, &c. that of an annuity on the same number of joint lives respectively one year younger than they.

Solution.

If it were certain that the lives ABC, &c. would all survive one year, the proprietor of an annuity of L.1 dependent upon their joint continuance would, at the expiration of a year, be in possession of L.1 (the first year's rent), and an annuity on the same number of lives one year older respectively than ABC, &c.; therefore, in that case, the required present value of the annuity would be $v[1 + '(\text{ABC}, \&c.)]$. (146.)

But the probability of the lives A, B, C, &c. jointly surviving one year is less than certainty in the ratio of ${}_1(abc, \&c.)$ to unit; therefore ABC, &c. $= {}_1(abc, \&c.)$ $v[1 + '(\text{ABC}, \&c.)]$.

150. *Corol.* 1. When there are but three lives, A, B, and C, this becomes ABC $= {}_1(abc)v[1 + '(\text{ABC})]$.

151. *Corol.* 2. When there are only two, A and B, AB $= {}_1(ab)v[1 + '(\text{AB})]$.

152. *Corol.* 3. And for a single life A, it appears, in the same manner, that A $= {}_1av(1 + 'A)$.

153. Hence, in logarithms, we have these equations,

$$\lambda A = \lambda v + \lambda {}_1a + \lambda(1 + 'A),$$
$$\lambda AB = \lambda v + \lambda {}_1a + \lambda {}_1b + \lambda[1 + '(AB)],$$
$$\lambda ABC = \lambda v + \lambda {}_1a + \lambda {}_1b + \lambda {}_1c + \lambda[1 + '(ABC)],$$
$$\&c. \qquad \&c. \qquad \&c.$$

Upon which it may be observed, that $\lambda v + \lambda {}_1a$, the sum of the first two logarithms that are employed in determining A from $'$A, also enters the operation whereby AB is determined from $'$(AB). And that $\lambda v + \lambda {}_1a + \lambda {}_1b$, the sum of the first three logarithms that serve to determine AB from $'$(AB), is also required to determine ABC from $'$(ABC); which observation may be extended in a similar manner to any greater number of joint lives.

154. By these means it is easy to complete a table of the values of annuities on single lives of all ages, beginning with the oldest in the table, and proceeding regularly age by age to the youngest.

Also a table of the values of any number of joint lives, the lives in each succeeding combination, in any one series of operations (according to the retrograde order of the ages in which they are computed), being one year younger respectively than those in the preceding combination.

And, if a table of single lives be computed first, then of two joint lives, next of three joint lives, and so on, the calculations made for the preceding tables will be of great use for the succeeding.

155. Having shown how to compute tables of the values of annuities on single and joint lives, we shall, in what follows, always suppose those values to be given.

156. Let the value of an annuity on the joint continuance of any number of lives, A, B, C, &c. that is not to be entered upon until the expiration of t years, be denoted by $\neg^t$(ABC, &c.).

Then, if it were certain that all the lives would survive the term, since the value of the annuity at the expiration of the term would be ^{t}(ABC, &c.) (145), its present value would be $v^t . {}^t$(ABC, &c.) (146).

But the measure of the probability that all the lives will survive the term is ${}_t(abc, \&c.)$, therefore $\neg^t(\text{ABC}, \&c.) =$ ${}_t(abc, \&c.)\ v^t.\ {}^t(\text{ABC}, \&c.)$.

In the same manner, it appears, that for a single life A, $\neg^t A = {}_t av^t.\ {}^t A$.

157. Let an annuity for the term of t years only, dependent upon the joint continuance of any number of lives, A, B, C, &c. be denoted by $\underset{t|}{-}$(ABC, &c.); and, since this *temporary* annuity, together with an annuity on the joint continuance of the same lives *deferred* for the same term, will evidently be of the same value as an annuity to be entered upon immediately, and enjoyed during their whole joint continuance, we have $\underset{t|}{-}(\text{ABC}, \&c.) +$ $\neg^t$ (ABC, &c.) $=$ ABC, &c.; whence, $\underset{t|}{-}(\text{ABC}, \&c.) =$ ABC, &c. $- \neg$ (ABC, &c.).

And for a single life A, $\underset{t|}{-}A = A - \neg^t A$.

PROB. II.

158. To determine the present value of an annuity on the survivor of the two lives A and B (155); which we designate thus, $\overline{AB}$.

Solution.

The probability that the survivor of these two lives will outlive the term of n years was shown in No. 141 to be ${}_na + {}_nb - {}_n(ab)$; therefore, reasoning as in No. 146, it will be found that the present value of the nth year's rent of this annuity is $[{}_na + b - {}_n(ab)]v^n$, and the value of all the rents thereof will be $S[{}_na + {}_nb - {}_n(ab)]v^n$, or $S_n av^n + S_n bv^n - S_n(ab)\ v^n$; so that $\overline{AB} = A + B - AB$ (147), agreeably to No. 48.

PROB. III.

159. To determine the present value of an annuity on the last survivor of three lives, A, B, and C (155); which we denote thus, $\overline{ABC}$.

Solution.

The present value of the nth year's rent is $[{}_na + {}_nb + {}_nc - {}_n(ab) - {}_n(ac) - {}_n(bc) + {}_n(abc)]v^n$ (142 and 146); whence, it appears, as in the preceding number, that $\overline{ABC} = A + B + C - AB - AC - BC + ABC$, agreeably to No. 52.

PROB. IV.

160. To determine the present value of an annuity on the joint existence of the last two survivors out of three lives, A, B, C, (155); which we denote thus, $\overset{2}{\overline{\text{ABC}}}$.

Solution.

The present value of the nth year's rent is $[{}_n(ab) + {}_n(ac) + {}_n(bc) - 2{}_n(abc)]v^n$ (143 and 146); whence, reasoning as in the two preceding numbers, we infer, that $\overset{2}{\overline{\text{ABC}}} = \text{AB} + \text{AC} + \text{BC} - 2\,\text{ABC}$, as was demonstrated otherwise in No. 51.

161. Since the solutions of the last three problems were all obtained by showing each year's rent (as for instance the nth) of the annuity in question to be of the same value with the aggregate of the rents for the same year of all the annuities (taken with their proper signs) on the single and joint lives exhibited in the resulting formula; if any term of years be assigned, it is manifest that the value of such annuity for the term must be the same as that of the aggregate of the annuities above mentioned, each for the same term.

PROB. V.

162. A and B being any two proposed lives now both existing, to determine the present value of an annuity receivable only while A survives B.

Solution.

A rent of this annuity will only be payable at the end of the nth year, provided that B be then dead and A living; but the probability of B being then dead is $1 - {}_nb$, and that of A being then living ${}_na$, and these two events are independent; therefore, the probability of their both happening, or that of the rent being received, is $(1 - {}_nb)\,{}_na = {}_na - {}_n(ab)$; the present value of that rent is, therefore, $[{}_na - {}_n(ab)]v^n$; whence it follows, that the required value of the annuity on the life of A after that of B is $\text{A} - \text{AB}$, agreeably to No. 60.

163. If the payment for the annuity which was the subject of the last problem is not to be made in present money, but by a constant annual premium p at the end of each year, while both the lives survive; since AB is the number of years' purchase (6) that an annuity on the joint continuance of those lives is worth, the value of p will be determined by this equation, $\text{p} \cdot \text{AB} = \text{A} - \text{AB}$, whence we have $\text{p} = \frac{\text{A}}{\text{AB}} - 1$.

164. But if one premium p is to be paid down now, and an equal premium at the end of each year while both the lives survive, we shall have $p \cdot (1 + \text{AB}) = \text{A} - \text{AB}$, and $p = \frac{\text{A} - \text{AB}}{1 + \text{AB}}$.

165. For numerical examples illustrative of the formulæ given from No. 158 to the present, see Nos. 66–74.

PROB. VI.

166. A and B are in possession of an annuity on the life of the survivor of them, which, if either of them die before a third person C, is then to be divided equally between C and the survivor during their joint lives; to determine the value of C's interest.

Solution.

That at the end of the nth year there will be: dead	living	the probability, multiplied by C's proportion of the annuity in that circumstance, is
A	BC	$\frac{1}{2}(1 - {}_na) \cdot {}_n(bc) = \frac{1}{2}[{}_n(bc) - {}_n(abc)]$
B	AC	$\frac{1}{2}(1 - {}_nb) \cdot {}_n(ac) = \frac{1}{2}[{}_n(ac) - {}_n(abc)]$;

and the sum of these being $\frac{1}{2}\,{}_n(ac) + \frac{1}{2}\,{}_n(bc) - {}_n(abc)$, the value of C's interest is $\frac{1}{2}\,\text{AC} + \frac{1}{2}\,\text{BC} - \text{ABC}$.

PROB. VII.

167. An annuity, after the decease of A, is to be equally divided between B and C during their joint lives, and is then to go entirely to the last survivor for his life; it is proposed to find the value of B's interest therein.

Solution.

That at the end of the nth year there will be: dead	living	the probability, multiplied by B's proportion of the annuity in that circumstance, is
A	BC	$\ldots\ldots\ldots\ldots + \frac{1}{2}{}_n(bc) - \frac{1}{2}{}_n(abc)$
AC	B	${}_nb - {}_n(ab) - {}_n(bc) + {}_n(abc)$; and the sum

of these being ${}_nb - {}_n(ab) - \frac{1}{2}{}_n(bc) + \frac{1}{2}{}_n(abc)$, the value of B's interest is $\text{B} - \text{AB} - \frac{1}{2}\,\text{BC} + \frac{1}{2}\,\text{ABC}$.

PROB. VIII.

168. A, B, and C purchase an annuity on the life of the last survivor of them, which is to be divided equally at the end of every year among such of them as may then be living; what should A contribute towards the purchase of this annuity?

Solution.

That at the end of n years there will be: dead	living	the probability, multiplied by A's proportion of the annuity in that circumstance, is
none	ABC	$\ldots\ldots\ldots\ldots\ldots\ldots + \frac{1}{3}{}_n(abc)$
C	AB	$\ldots + \frac{1}{2}{}_n(ab) \ldots\ldots - \frac{1}{2}{}_n(abc)$
B	AC	$\ldots\ldots\ldots + \frac{1}{2}{}_n(ac) - \frac{1}{2}{}_n(abc)$
BC	A	${}_na - {}_n(ab) - {}_n(ac) + {}_n(abc)$; and the sum

of these being ${}_na - \frac{1}{2}{}_n(ab) - \frac{1}{2}{}_n(ac) + \frac{1}{3}{}_n(abc)$, the required value of A's interest is $\text{A} - \frac{1}{2}\,\text{AB} - \frac{1}{2}\,\text{AC} + \frac{1}{3}\,\text{ABC}$.

PROB. IX.

169. As soon as any two of the three lives, A, B, and C, are extinct, D or his heirs are to enter upon an annuity, which they are to enjoy during the remainder of the survivor's life; to determine the value of D's interest therein.

Solution.

That at the end of n years there will be: dead	living	The probability is
AB	C	${}_nc - {}_n(ac) - {}_n(bc) + {}_n(abc)$
AC	B	${}_nb - {}_n(ab) - {}_n(bc) + {}_n(abc)$
BC	A	${}_na - {}_n(ab) - {}_n(ac) + {}_n(abc)$; and the sum

of all these being ${}_na + {}_nb + {}_nc - 2{}_n(ab) - 2{}_n(ac) - 2{}_n(bc) + 3{}_n(abc)$, the value of D's interest is

$$\text{A} + \text{B} + \text{C} - 2\,\text{AB} - 2\,\text{AC} - 2\,\text{BC} + 3\,\text{ABC}.$$

170. The last four may be sufficient to show the method of proceeding with any similar problems.

171. Let ${}_t\left(\frac{m}{abc,\ \&c.}\right)$ denote the probability that the last m survivors out of $m + \mu$ lives A, B, C, &c. will jointly survive the term of t years. And when $\mu = 0$, the expression will become ${}_t(abc, \&c.)$, the probability that the lives will all survive the term. (138.)

When $m = 1$ it will become ${}_t\left(\frac{1}{abc,\ \&c.}\right)$, the measure of

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the probability that the last survivor of them will outlive the term, which it will be better to write thus, ${}_t\overline{(abc, \&c.)}$, retaining the vinculum, but omitting the unit over it, as in the notation of powers.

Also let $\overline{\overset{m}{\text{ABC}}, \&c.}$ denote the value of an annuity on the joint continuance of the same number of last survivors out of the same lives. Then, if μ be equal to 0, it will be $\overline{\text{ABC}, \&c.}$ the value of an annuity on the joint continuance of all the lives; when $m=1$, it will be $\overline{\text{ABC}, \&c.}$ the value of an annuity on the last survivor of them. The values of annuities on the last survivor of two and of three lives will be denoted as in Nos. 158 and 159 respectively; and that of an annuity on the joint continuance of the last two survivors out of three lives, as in No. 160.

The value of an annuity on the last m survivors out of these $m+\mu$ lives, according as it is limited to the term of t years, or deferred during that term, will also be denoted by $\underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}$ or ${}_{t|}\overline{\overset{m}{\text{ABC}}, \&c.}$ (156 and 157.)

PROB. X.

172. An annuity certain for the term of $t+\nu$ years is to be enjoyed by P and his heirs during the joint existence of the last m survivors out of $m+\mu$ lives, A, B, C, &c.; and if that joint existence fail before the expiration of t years, the annuity is to go to Q and his heirs for the remainder of the term; to determine the value of Q's interest in that annuity.

Solution.

Q's expectation may be distinguished into two parts:

1*st*, That of enjoying the annuity during the term of t years.

2*d*, That of enjoying it after the expiration of that term.

The sum of the present values of the interests of P and Q together in the annuity for the term of t years, is manifestly equal to the whole present value of the annuity certain for that term; that is, equal to $\frac{1-v^t}{r}$ (113 and 146); and the value of P's interest for the term of t years is $\underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}$ (171); therefore the value of Q's interest for the same term is $\frac{1-v^t}{r} - \underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}$

The present value of the annuity certain for ν years after t years is $\frac{v^t(1-v^\nu)}{r}$ (114 and 146); and Q and his heirs will receive this annuity if the joint continuance of the last m survivors above mentioned fail before the expiration of t years; but the probability of their joint continuance failing in the term is $1-{}_t\overline{\left(\overset{m}{abc}, \&c.\right)}$; therefore the value of Q's interest in the annuity to be received after t years, is $\left[1-{}_t\overline{\left(\overset{m}{abc}, \&c.\right)}\right]\frac{v^t(1-v^\nu)}{r}$; and the whole value of Q's interest is

$$\frac{1}{r}\left[1-v^{\nu+t}-v^t(1-v^\nu)\cdot{}_t\overline{\left(\overset{m}{abc}, \&c.\right)}\right]-\underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}$$

173. *Corol.* 1. When the whole annuity certain is a perpetuity, $v^{t+\nu}=0$, and the value of Q's interest is

$$\frac{1}{r}\left[1-{}_t\overline{\left(\overset{m}{abc}, \&c.\right)}v^t\right]-\underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}$$

174. *Corol.* 2. When the term t is not less than the greatest joint continuance of any m of the proposed lives, according to the tables of mortality adapted to them, ${}_t\overline{\left(\overset{m}{abc}, \&c.\right)}=0$, and $\underset{t|}{\overline{\overset{m}{\text{ABC}}, \&c.}}=\overline{\overset{m}{\text{ABC}}, \&c.}$; therefore, in that case, the general formula of No. 172 becomes $\frac{1-v^{\nu+t}}{r}-\overline{\overset{m}{\text{ABC}}, \&c.}$; that is, the excess of the value of an annuity certain for the whole term $\nu+t$, above that of an annuity on the whole duration of joint continuance of the last m surviving lives.

175. And if, in the case proposed in the last No., the annuity certain be a perpetuity, as in No. 173, the formula will become $\frac{1}{r}-\overline{\overset{m}{\text{ABC}}, \&c.}$ the excess of the value of the perpetuity above the value of an annuity on the joint lives of the last m survivors; agreeably to No. 63.

176. *Example* 1. Required the present value of the absolute reversion of an estate in fee simple, after the extinction of the last survivor of three lives, A, B, C, now aged 50, 55, and 60 years respectively; reckoning interest at 5 *per cent.*

The general algebraical expression of this value has just been shown to be $\frac{1}{r}-\overline{\text{ABC}}$.

$$\text{But } \frac{1}{r}=\frac{1}{0{\cdot}5}=20{\cdot}000$$

$$\text{And } \overline{\text{ABC}}, \quad =14{\cdot}001 \text{ (68.)}$$

Therefore 5·999 years' purchase is the value required. And if the annual produce of the estate, clear of all deductions, were L.100, the title to the reversion would now be worth L.599. 18s. —, agreeably to No. 76.

177. *Ex.* 2. An annuity for the term of 70 years certain (from this time) is to revert to Q and his heirs at the failure of a life A, now 45 years of age; what is the present value of Q's interest therein, reckoning the interest of money at 5 *per cent.*?

In No. 174 the algebraical expression of the required value is shown to be $\frac{1-v^{70}}{r}-\text{A}$.

$$\text{But } \lambda.v=\varkappa 1{\cdot}05=\bar{1}{\cdot}9788107$$
$$\times 70$$
$$v^{70}=\cdot032866\lambda\bar{2}{\cdot}5167490$$
$$1-v^{70}=\cdot967134$$
$$\frac{1-v^{70}}{r}=\frac{\cdot967134}{\cdot05}=19{\cdot}34268$$
$$\text{Subtract A}=12{\cdot}64800 \text{ (Tab. VI.)}$$

remains 6·69468 years' purchase; so that if the annuity were L.1000, the value of the reversion would be L.6694. 13s. 7d.

178. *Ex.* 3. An annuity for the term of 70 years certain from this time is to revert to Q and his heirs at the extinction of the survivor of two lives, A and B, now aged 40 and 50 years respectively, the interest of money being 5 *per cent.*; it is required to determine the value of Q's interest in this annuity.

The algebraical expression of the value is, $\frac{1-v^{70}}{r}-\overline{\text{AB}}$ (174 and 171).

$$\text{But by the last example } \frac{1-v^{70}}{r}=19{\cdot}34268$$
$$\text{and by No. 66, } \overline{\text{AB}}=15{\cdot}06600$$

so that the required value is 4·27668 years'

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purchase; and if the annuity be L.1000, the present value of the reversion will be L.4276. 13s. 7d.

IV.—Of Assurances on Lives.

179. Let the present value of the assurance (77 and 78) of L.1 on the life of A be denoted by the old English capital $\mathfrak{A}$, and that of an assurance on the joint continuance of any number of lives A, B, C, &c. by $\mathfrak{ABC}$, &c. Also, let the value of an assurance on the joint continuance of any m of them out of the whole number $m+\mu$ be denoted by $\overset{m}{\overline{\mathfrak{ABC}}}$, &c.

180. And, in every case, let us designate the annual premium (83) for an assurance, by prefixing the character $\odot$ to the symbol for the single premium; so that $\odot\mathfrak{A}$ may denote the annual premium for an assurance on the life of A; $\odot\mathfrak{ABC}$, &c. the same for an assurance on the joint continuance of all the lives, A, B, C, &c.; and $\odot\overset{m}{\overline{\mathfrak{ABC}}}$, &c. the annual premium for an assurance on the joint continuance of the last m survivors out of the whole number $m+\mu$ of those lives.

181. Then will ${}_{\overline{t|}}\mathfrak{A}$ and $\odot\,{}_{\overline{t|}}\mathfrak{A}$, ${}_{\overline{t|}}\mathfrak{ABC}$, &c. and $\odot\,{}_{\overline{t|}}\mathfrak{ABC}$, &c., ${}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}$, &c. and $\odot\,{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}$, &c. designate the single and annual premiums for assurances on the same life or lives for the term of t years only.

Prob. XI.

182. To determine $\left({}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}, \text{\&c.}\right)$ the present value of an assurance on the last m survivors out of $m+\mu$ lives A, B, C, &c. for the term of t years only; that is, the present value of L.1 to be received upon the joint continuance of these last m survivors failing in the term.

Solution.

By reasoning as in No. 79, it will be found that a perpetuity, the first payment of which is to be made at the end of the year in which the last m survivors out of these $m+\mu$ lives may fail in the term, will be of the same present value as $\left(1+\frac{1}{r}=\right)\frac{1}{1-v}$ pounds to be received in the same event (112 and 146); but, in No. 173, the value of the reversion of such a perpetuity in that event was shown to be $\frac{v}{1-v}\left[1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t\right]-{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}$

whence it is manifest that ${}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}$, &c.

$$= v\left[1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}\,v^t\right]-(1-v)\,{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}$$

183. Since the annual premium for this assurance must be paid at the commencement of every year in the term, while the last m surviving lives all subsist (83); besides the premium paid down now, one must be paid at the expiration of every year in the term except the last, provided that these last m survivors all outlive it; but the present value of L.1 to be received upon their surviving that last year is ${}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t$, therefore all the future premiums are now worth ${}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}\,v^t$ years' purchase, and the present value of all the premiums, or the total present value of the assurance, is

$$\odot\,{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}, \text{\&c.}\left[1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}\,v^t+{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}\right]=$$

$$v\left[1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t\right]-(1-v)\,{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}=1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t$$

$$-(1-v)\,.\left[1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t+{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}\right],$$ whence we have

$$\odot\,{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}}}, \text{\&c.}=\frac{1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}\,v^t}{1-{}_t\overset{m}{\overline{(abc, \text{\&c.})}}v^t+{}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}}+v-1.$$

184. *Corol.* 1. When (t), the term of the assurance, is not less than the greatest possible joint duration of any m of the proposed lives, ${}_t\overset{m}{\overline{(abc, \text{\&c.})}}=0$, ${}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}=\overset{m}{\overline{\text{ABC, \&c.}}}$, and the general formulæ of the two preceding numbers become respectively

$$\overset{m}{\overline{\mathfrak{ABC}}}, \text{\&c.}=v-(1-v)\,\overset{m}{\overline{\text{ABC, \&c.}}}$$

$$\text{and } \odot\,\overset{m}{\overline{\mathfrak{ABC}}}, \text{\&c.}=\frac{1}{1+\overset{m}{\overline{\text{ABC, \&c.}}}}+v-1.$$

185. *Corol.* 2. In the same manner it appears, that, for a single life, $\mathfrak{A}=v-(1-v)\,\text{A}$,

$$\text{and } \odot\mathfrak{A}=\frac{1}{1+\text{A}}+v-1.$$

186. *Corol.* 3. Also that ${}_{\overline{t|}}\mathfrak{A}=v(1-{}_ta\,v^t)-(1-v)\,{}_{\overline{t|}}\text{A}$

$$\text{or } {}_{\overline{t|}}\mathfrak{A}=v\left(1-\frac{{}^ta}{a}v^t\right)-(1-v)\,.\left(\text{A}-\frac{{}^ta}{a}v^t\,.\,{}^t\text{A}\right).$$

$$\text{And } \odot\,{}_{\overline{t|}}\mathfrak{A}=\frac{1-{}_tav^t}{1-{}_ta\,v^t+{}_{\overline{t|}}\text{A}}+v-1;$$

$$\text{that is, } \odot\,{}_{\overline{t|}}\mathfrak{A}=\frac{1-\frac{{}^ta}{a}v^t}{1+\text{A}-\frac{{}^ta}{a}v^t\,.\,(1+{}^t\text{A})}+v-1.$$

187. *Corol.* 4. When the assurance is on the joint continuance of all the lives, the formulæ of No. 184 become respectively

$$\mathfrak{ABC}, \text{\&c.}=v-(1-v)\,\text{ABC, \&c.}$$

$$\text{and } \odot\,\mathfrak{ABC}, \text{\&c.}=\frac{1}{1+\text{ABC, \&c.}}+v-1.$$

And those of numbers 182 and 183,

$${}_{\overline{t|}}\mathfrak{ABC}, \text{\&c.}=v\left(1-\frac{{}^t(abc, \text{\&c.})}{abc, \text{\&c.}}v^t\right)-(1-v)\times$$

$$\left[\text{ABC, \&c.}-\frac{{}^t(abc, \text{\&c.})}{abc, \text{\&c.}}v^t\,.\,{}^t(\text{ABC, \&c.})\right]$$

and $\odot\,{}_{\overline{t|}}\mathfrak{ABC}$, &c. =

$$\frac{1-\frac{{}^t(abc, \text{\&c.})}{abc, \text{\&c.}}v^t}{1+\text{ABC, \&c.}-\frac{{}^t(abc, \text{\&c.})}{abc, \text{\&c.}}v^t\left[1+{}^t(\text{ABC, \&c.})\right]},$$

$+v-1.$

188. *Corol.* 5. According as the assurance is in the last survivor of two or of three lives, the formulæ of No. 184 become respectively

Algebraical View.

$$\overline{\mathfrak{AB}} = v - (1 - v)\,\overline{\text{AB}},$$

$$\text{and } \odot\,\overline{\mathfrak{AB}} = \frac{1}{1 + \overline{\text{AB}}} + v - 1;$$

$$\text{or } \overline{\mathfrak{ABC}} = v - (1 - v)\,\overline{\text{ABC}},$$

$$\text{and } \odot\,\overline{\mathfrak{ABC}} = \frac{1}{1 + \overline{\text{ABC}}} + v - 1.$$

And those of numbers 182 and 183 become

$$_{\overline{t|}}\overline{\mathfrak{AB}} = v\left[1 - {}_t(\overline{ab})v^t\right] - (1 - v)\,_{\overline{t|}}\overline{\text{AB}},$$

$$\text{and } \odot\,_{\overline{t|}}\overline{\mathfrak{AB}} = \frac{1 - {}_t(\overline{ab})v^t}{1 - {}_t(\overline{ab})v^t + {}_{\overline{t|}}\overline{\text{AB}}} + v - 1;$$

$$\text{or } _{\overline{t|}}\overline{\mathfrak{ABC}} = v\left[1 - {}_t(\overline{abc})v^t\right] - (1 - v)\,_{\overline{t|}}\overline{\text{ABC}},$$

$$\text{and } \odot\,_{\overline{t|}}\overline{\mathfrak{ABC}} = \frac{1 - {}_t(\overline{abc})v^t}{1 - {}_t(abc)v^t + {}_{\overline{t|}}\overline{\text{ABC}}} + v - 1 \text{ respectively.}$$

Where ${}_t(\overline{ab}) = {}_ta + {}_tb - {}_t(ab)$ (141),

and ${}_t(\overline{abc}) = {}_ta + {}_tb + {}_tc - \left[{}_t(ab) + {}_t(ac) + {}_t(bc)\right] + {}_t(abc)$. (142.)

For the values of $\overline{\text{AB}}$, $\overline{\text{ABC}}$, $_{\overline{t|}}\overline{\text{AB}}$, and $_{\overline{t|}}\overline{\text{ABC}}$, see numbers 157–159, and 161.

189. *Corol.* 6. When the assurance is on the joint continuance of the two last survivors out of the three lives *A, B, C,* the formulæ of No. 184 become respectively

$$\overset{2}{\overline{\mathfrak{ABC}}} = v - (1 - v)\overset{2}{\overline{\text{ABC}}},$$

$$\text{and } \odot\,\overset{2}{\overline{\mathfrak{ABC}}} = \frac{1}{1 + \overset{2}{\overline{\text{ABC}}}} + v - 1.$$

Those of numbers 182 and 183,

$$_{\overline{t|}}\overset{2}{\overline{\mathfrak{ABC}}} = v\left[1 - {}_t\overset{2}{(\overline{abc})}v^t\right] - (1 - v)\,_{\overline{t|}}\overset{2}{\overline{\text{ABC}}},$$

$$\text{and } \odot\,_{\overline{t|}}\overset{2}{\overline{\mathfrak{ABC}}} = \frac{1 - {}_t\overset{2}{(\overline{abc})}v^t}{1 - {}_t\overset{2}{(\overline{abc})}v^t + {}_{\overline{t|}}\overset{2}{\overline{\text{ABC}}}} + v - 1.$$

Where ${}_t\overset{2}{(\overline{abc})} = {}_t(ab) + {}_t(ac) + {}_t(bc) - 2\,{}_t(abc)$. (143.)

For the values of $\overset{2}{\overline{\text{ABC}}}$ and $_{\overline{t|}}\overset{2}{\overline{\text{ABC}}}$ see numbers 157, 160, and 161.

190. $v\left[1 - {}_t\overset{m}{(\overline{abc, \&c.})}v^t\right] - (1 - v)\,_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}$ the value of an assurance on any life or lives for the term of t years, which was given in No. 182, may also be expressed thus:

$$\left[1 + {}_{\overline{t|}}\overset{m}{(\overline{\text{ABC, \&c.}})} - {}_t\overset{m}{(\overline{abc, \&c.})}v^t\right]v - {}_{\overline{t|}}\overset{m}{\overline{\text{ABC, \&c.}}}$$

And this, in words at length, is the rule given in No. 93.

191. When t is not less than the greatest possible joint duration of any m of the proposed lives, the last expression becomes

$$\left(1 + \overset{m}{\overline{\text{ABC, \&c.}}}\right)v - \overset{m}{\overline{\text{ABC, \&c.}}}$$

which is also equivalent to the first in No. 184; and, in words at length, is the rule given in No. 97 for determining the value of an assurance on any life or lives for their whole duration.

192. By substituting $\frac{1}{1 + r}$ for v (146) in the last expression, it becomes $\frac{1 + \overset{m}{\overline{\text{ABC, \&c.}}}}{1 + r} - \overset{m}{\overline{\text{ABC, \&c.}}}$

$= \frac{1 - r\,.\,\overset{m}{\overline{\text{ABC, \&c.}}}}{1 + r}$, or $\frac{\frac{1}{r} - \overset{m}{\overline{\text{ABC, \&c.}}}}{1 + \frac{1}{r}}$. And

$\frac{\frac{1}{r} - \overset{m}{\overline{\text{ABC, \&c.}}}}{1 + \frac{1}{r}} = \overset{m}{\overline{\mathfrak{ABC}}}$, &c. is the proposition enunciated in No. 81; $\frac{1}{r}$ being the value of the perpetuity. (112.)

193. Examples of the determination of the single premiums for assurances, and of the derivation of the annual premiums from them, have been given in No. 82–88, also in 95 and 96; but by the algebraical formulæ given here, the annual premiums may be determined directly, without first finding the total present values of the assurances.

194. *Example* 1. Required the annual premium for an assurance on the life *A*, now 50 years of age, interest 5 *per cent.*

According to No. 185, the operation is thus,

$$\left.\begin{aligned} 1 + \text{A} &= 12{\cdot}660\ \lambda \\ \frac{1}{1 + \text{A}} &= {\cdot}0789890\ \varkappa \end{aligned}\right\}\ \bar{2}{\cdot}8975663$$

adding $v = {\cdot}9523809$, and subtracting unit, we have $\odot\,\mathfrak{A}$ ${\cdot}0313699$, agreeably to No. 85.

195. *Ex.* 2. What should the annual premium be for an assurance on the last survivor of three lives *A, B,* and *C,* now aged 50, 55, and 60 years respectively, rate of interest 5 *per cent.*?

Operation by No. 188.

$$\left.\begin{aligned} (68)\ 1 + \overline{\text{ABC}} &= 15{\cdot}001\ \lambda \\ \frac{1}{1 + \overline{\text{ABC}}} &= {\cdot}0666622\ \varkappa \end{aligned}\right\}\ \bar{2}{\cdot}8238798$$

$$v = {\cdot}9523809$$

$$\odot\,\overline{\mathfrak{ABC}} = {\cdot}0190431, \text{ agreeably to No. 88.}$$

196. *Ex.* 3. Required the annual premium for an assurance for 10 years only, on a life now 45 years of age, interest 5 *per cent.*

Operation according to No. 186.

$$\begin{aligned} v^{10} &= {\cdot}613913\ \lambda\ \bar{1}{\cdot}7881068 \\ {}_{10}a &= 4073\ \lambda\ 3{\cdot}6099144 \\ a &= 4727\ \varkappa\ \bar{4}{\cdot}3254144 \\ \hline {}_{10}av^{10} &= {\cdot}528976\ \lambda\ \bar{1}{\cdot}7234356 \\ 1 + {}_{10}\text{A} &= 11{\cdot}347\ \lambda\ 1{\cdot}0548811 \\ \hline \text{Subtract} \quad & \quad 6{\cdot}002\ \lambda\ 0{\cdot}7783167 \\ \text{from } 1 + \text{A} &= 13{\cdot}648 \\ \hline \text{remains} \quad & \quad 7{\cdot}646\ \varkappa\ \bar{1}{\cdot}1165657 \\ 1 - {}_{10}av^{10} &= {\cdot}471024\ \lambda\ \bar{1}{\cdot}6730430 \\ \hline & \quad {\cdot}061604\ \lambda\ \bar{2}\ 7896087 \\ v &= {\cdot}952381 \\ \hline \end{aligned}$$

$$\odot\,_{\overline{10|}}\mathfrak{A} = {\cdot}013985, \text{ agreeably to No. 96.}$$

What has been advanced from number 99 to 109 needs no algebraical illustration.

TABLE I.

Showing the present Value of One Pound to be received at the End of any Number of Years not exceeding 50.

(See No. 9——12 of the preceding Article.)

Years.	2 per Cent.	2½ per Cent.	3 per Cent.	4 per Cent.	5 per Cent.	6 per Cent.	7 per Cent.	8 per Cent.	9 per Cent.	Years.
1	·980392	·975610	·970874	·961538	·952381	·943396	·934579	·925926	·917431	1
2	·961169	·951814	·942596	·924556	·907029	·889996	·873439	·857339	·841680	2
3	·942322	·928599	·915142	·888996	·863838	·839619	·816298	·793832	·772183	3
4	·923845	·905951	·888487	·854804	·822702	·792094	·762895	·735030	·708425	4
5	·905731	·883854	·862609	·821927	·783526	·747258	·712986	·680583	·649931	5
6	·887971	·862297	·837484	·790315	·746215	·704961	·666342	·630170	·596267	6
7	·870560	·841265	·813092	·759918	·710681	·665057	·622750	·583490	·547034	7
8	·853490	·820747	·789409	·730690	·676839	·627412	·582009	·540269	·501866	8
9	·836755	·800728	·766417	·702587	·644609	·591898	·543934	·500249	·460428	9
10	·820348	·781198	·744094	·675564	·613913	·558395	·508349	·463193	·422411	10
11	·804263	·762145	·722421	·649581	·584679	·526788	·475093	·428883	·387533	11
12	·788493	·743556	·701380	·624597	·556837	·496969	·444012	·397114	·355535	12
13	·773033	·725420	·680951	·600574	·530321	·468839	·414964	·367698	·326179	13
14	·757875	·707727	·661118	·577475	·505068	·442301	·387817	·340461	·299246	14
15	·743015	·690466	·641862	·555265	·481017	·417265	·362446	·315242	·274538	15
16	·728446	·673625	·623167	·533908	·458112	·393646	·338735	·291890	·251870	16
17	·714163	·657195	·605016	·513373	·436297	·371364	·316574	·270269	·231073	17
18	·700159	·641166	·587395	·493628	·415521	·350344	·295864	·250249	·211994	18
19	·686431	·625528	·570286	·474642	·395734	·330513	·276508	·231712	·194490	19
20	·672971	·610271	·553676	·456387	·376889	·311805	·258419	·214548	·178431	20
21	·659776	·595386	·537549	·438834	·358942	·294155	·241513	·198656	·163698	21
22	·646839	·580865	·521893	·421955	·341850	·277505	·225713	·183941	·150182	22
23	·634156	·566697	·506692	·405726	·325571	·261797	·210947	·170315	·137781	23
24	·621721	·552875	·491934	·390121	·310068	·246979	·197147	·157699	·126405	24
25	·609531	·539391	·477606	·375117	·295303	·232999	·184249	·146018	·115968	25
26	·597579	·526235	·463695	·360689	·281241	·219810	·172195	·135202	·106393	26
27	·585862	·513400	·450189	·346817	·267848	·207368	·160930	·125187	·097608	27
28	·574375	·500878	·437077	·333477	·255094	·195630	·150402	·115914	·089548	28
29	·563112	·488661	·424346	·320651	·242946	·184557	·140563	·107328	·082155	29
30	·552071	·476743	·411987	·308319	·231377	·174110	·131367	·099377	·075371	30
31	·541246	·465115	·399987	·296460	·220359	·164255	·122773	·092016	·069148	31
32	·530633	·453771	·388337	·285058	·209866	·154957	·114741	·085200	·063438	32
33	·520229	·442703	·377026	·274094	·199873	·146186	·107235	·078889	·058200	33
34	·510028	·431905	·366045	·263552	·190355	·137912	·100219	·073045	·053395	34
35	·500028	·421371	·355383	·253415	·181290	·130105	·093663	·067635	·048986	35
36	·490223	·411094	·345032	·243669	·172657	·122741	·087535	·062625	·044941	36
37	·480611	·401067	·334983	·234297	·164436	·115793	·081809	·057986	·041231	37
38	·471187	·391285	·325226	·225285	·156605	·109239	·076457	·053690	·037826	38
39	·461948	·381741	·315754	·216621	·149148	·103056	·071455	·049713	·034703	39
40	·452890	·372431	·306557	·208289	·142046	·097222	·066780	·046031	·031838	40
41	·444010	·363347	·297628	·200278	·135282	·091719	·062412	·042621	·029209	41
42	·435304	·354485	·288959	·192575	·128840	·086527	·058329	·039464	·026797	42
43	·426769	·345839	·280543	·185168	·122704	·081630	·054513	·036541	·024584	43
44	·418401	·337404	·272372	·178046	·116861	·077009	·050946	·033834	·022555	44
45	·410197	·329174	·264439	·171198	·111297	·072650	·047613	·031328	·020692	45
46	·402154	·321146	·256737	·164614	·105997	·068538	·044499	·029007	·018984	46
47	·394268	·313313	·249259	·158283	·100949	·064658	·041587	·026859	·017416	47
48	·386538	·305671	·241999	·152195	·096142	·060998	·038867	·024869	·015978	48
49	·378958	·298216	·234950	·146341	·091564	·057546	·036324	·023027	·014659	49
50	·371528	·290942	·228107	·140713	·087204	·054288	·033948	·021321	·013449	50

TABLE II.

Showing the present Value of an Annuity of One Pound for any Number of Years not exceeding 50.

No. 9——12.

Years.	2 per Cent.	2½ per Cent.	3 per Cent.	4 per Cent.	5 per Cent.	6 per Cent.	7 per Cent.	8 per Cent.	9 per Cent.	Years.
1	·9804	·9756	·9709	·9615	·9524	·9434	·9346	·9259	·9174	1
2	1·9416	1·9274	1·9135	1·8861	1·8594	1·8334	1·8080	1·7833	1·7591	2
3	2·8839	2·8560	2·8286	2·7751	2·7232	2·6730	2·6243	2·5771	2·5313	3
4	3·8077	3·7620	3·7171	3·6299	3·5460	3·4651	3·3872	3·3121	3·2397	4
5	4·7135	4·6458	4·5797	4·4518	4·3295	4·2124	4·1002	3·9927	3·8897	5
6	5·6014	5·5081	5·4172	5·2421	5·0757	4·9173	4·7665	4·6229	4·4859	6
7	6·4720	6·3494	6·2303	6·0021	5·7864	5·5824	5·3893	5·2064	5·0330	7
8	7·3255	7·1701	7·0197	6·7327	6·4632	6·2098	5·9713	5·7466	5·5348	8
9	8·1622	7·9709	7·7861	7·4353	7·1078	6·8017	6·5152	6·2469	5·9952	9
10	8·9826	8·7521	8·5302	8·1109	7·7217	7·3601	7·0236	6·7101	6·4177	10
11	9·7868	9·5142	9·2526	8·7605	8·3064	7·8869	7·4987	7·1390	6·8052	11
12	10·5753	10·2578	9·9540	9·3851	8·8633	8·3838	7·9427	7·5361	7·1607	12
13	11·3484	10·9832	10·6350	9·9856	9·3936	8·8527	8·3577	7·9038	7·4869	13
14	12·1062	11·6909	11·2961	10·5631	9·8986	9·2950	8·7455	8·2442	7·7862	14
15	12·8493	12·3814	11·9379	11·1184	10·3797	9·7122	9·1079	8·5595	8·0607	15
16	13·5777	13·0550	12·5611	11·6523	10·8378	10·1059	9·4466	8·8514	8·3126	16
17	14·2919	13·7122	13·1661	12·1657	11·2741	10·4773	9·7632	9·1216	8·5436	17
18	14·9920	14·3534	13·7535	12·6593	11·6896	10·8276	10·0591	9·3719	8·7556	18
19	15·6785	14·9789	14·3238	13·1339	12·0853	11·1581	10·3356	9·6036	8·9501	19
20	16·3514	15·5892	14·8775	13·5903	12·4622	11·4699	10·5940	9·8181	9·1285	20
21	17·0112	16·1845	15·4150	14·0292	12·8212	11·7641	10·8355	10·0168	9·2922	21
22	17·6580	16·7654	15·9369	14·4511	13·1630	12·0416	11·0612	10·2007	9·4424	22
23	18·2922	17·3321	16·4436	14·8568	13·4886	12·3034	11·2722	10·3711	9·5802	23
24	18·9139	17·8850	16·9355	15·2470	13·7986	12·5504	11·4693	10·5288	9·7066	24
25	19·5235	18·4244	17·4131	15·6221	14·0939	12·7834	11·6536	10·6748	9·8226	25
26	20·1210	18·9506	17·8768	15·9828	14·3752	13·0032	11·8258	10·8100	9·9290	26
27	20·7069	19·4640	18·3270	16·3296	14·6430	13·2105	11·9867	10·9352	10·0266	27
28	21·2813	19·9649	18·7641	16·6631	14·8981	13·4062	12·1371	11·0511	10·1161	28
29	21·8444	20·4535	19·1885	16·9837	15·1411	13·5907	12·2777	11·1584	10·1983	29
30	22·3965	20·9303	19·6004	17·2920	15·3725	13·7648	12·4090	11·2578	10·2737	30
31	22·9377	21·3954	20·0004	17·5885	15·5928	13·9291	12·5318	11·3498	10·3428	31
32	23·4683	21·8492	20·3888	17·8736	15·8027	14·0840	12·6466	11·4350	10·4062	32
33	23·9886	22·2919	20·7658	18·1476	16·0025	14·2302	12·7538	11·5139	10·4644	33
34	24·4986	22·7238	21·1318	18·4112	16·1929	14·3681	12·8540	11·5869	10·5178	34
35	24·9986	23·1452	21·4872	18·6646	16·3742	14·4982	12·9477	11·6546	10·5668	35
36	25·4888	23·5563	21·8323	18·9083	16·5469	14·6210	13·0352	11·7172	10·6118	36
37	25·9695	23·9573	22·1672	19·1426	16·7113	14·7368	13·1170	11·7752	10·6530	37
38	26·4406	24·3486	22·4925	19·3679	16·8679	14·8460	13·1935	11·8289	10·6908	38
39	26·9026	24·7303	22·8082	19·5845	17·0170	14·9491	13·2649	11·8786	10·7255	39
40	27·3555	25·1028	23·1148	19·7928	17·1591	15·0463	13·3317	11·9246	10·7574	40
41	27·7995	25·4661	23·4124	19·9931	17·2944	15·1380	13·3941	11·9672	10·7866	41
42	28·2348	25·8206	23·7014	20·1856	17·4232	15·2245	13·4524	12·0067	10·8134	42
43	28·6616	26·1664	23·9819	20·3708	17·5459	15·3062	13·5070	12·0432	10·8380	43
44	29·0800	26·5038	24·2543	20·5488	17·6628	15·3832	13·5579	12·0771	10·8605	44
45	29·4902	26·8330	24·5187	20·7200	17·7741	15·4558	13·6055	12·1084	10·8812	45
46	29·8923	27·1542	24·7754	20·8847	17·8801	15·5244	13·6500	12·1374	10·9002	46
47	30·2866	27·4675	25·0247	21·0429	17·9810	15·5890	13·6916	12·1643	10·9176	47
48	30·6731	27·7732	25·2667	21·1951	18·0772	15·6500	13·7305	12·1891	10·9336	48
49	31·0521	28·0714	25·5017	21·3415	18·1687	15·7076	13·7668	12·2122	10·9482	49
50	31·4236	28·3623	25·7298	21·4822	18·2559	15·7619	13·8007	12·2335	10·9617	50
Perp.	50·0000	40·0000	33·3333	25·0000	20·0000	16·6667	14·2857	12·5000	11·1111	Perp.

TABLE III.

Showing the Sum to which One Pound will increase when improved at Compound Interest during any Number of Years not exceeding 50.

(No. 9——12.)

Years.	2 per Cent.	2½ per Cent.	3 per Cent.	4 per Cent.	5 per Cent.	6 per Cent.	7 per Cent.	8 per Cent.	Years.
1	1·02000	1·02500	1·030000	1·040000	1·050000	1·060000	1·070000	1·080000	1
2	1·04040	1·05063	1·060900	1·081600	1·102500	1·123600	1·144900	1·166400	2
3	1·06121	1·07689	1·092727	1·124864	1·157625	1·191016	1·225043	1·259712	3
4	1·08243	1·10381	1·125509	1·169859	1·215506	1·262477	1·310796	1·360489	4
5	1·10408	1·13141	1·159274	1·216653	1·276282	1·338226	1·402552	1·469328	5
6	1·12616	1·15969	1·194052	1·265319	1·340096	1·418519	1·500730	1·586874	6
7	1·14869	1·18869	1·229874	1·315932	1·407100	1·503630	1·605781	1·713824	7
8	1·17166	1·21840	1·266770	1·368569	1·477455	1·593848	1·718186	1·850930	8
9	1·19509	1·24886	1·304773	1·423312	1·551328	1·689479	1·838459	1·999005	9
10	1·21899	1·28008	1·343916	1·480244	1·628895	1·790848	1·967151	2·158925	10
11	1·24337	1·31209	1·384234	1·539454	1·710339	1·898299	2·104852	2·331639	11
12	1·26824	1·34489	1·425761	1·601032	1·795856	2·012196	2·252192	2·518170	12
13	1·29361	1·37851	1·468534	1·665074	1·885649	2·132928	2·409845	2·719624	13
14	1·31948	1·41297	1·512590	1·731676	1·979932	2·260904	2·578534	2·937194	14
15	1·34587	1·44830	1·557967	1·800944	2·078928	2·396558	2·759032	3·172169	15
16	1·37279	1·48451	1·604706	1·872981	2·182875	2·540352	2·952164	3·425943	16
17	1·40024	1·52162	1·652848	1·947901	2·292018	2·692773	3·158815	3·700018	17
18	1·42825	1·55966	1·702433	2·025817	2·406619	2·854339	3·379932	3·996020	18
19	1·45681	1·59865	1·753506	2·106849	2·526950	3·025600	3·616528	4·315701	19
20	1·48595	1·63862	1·806111	2·191123	2·653298	3·207135	3·869684	4·660957	20
21	1·51567	1·67958	1·860295	2·278768	2·785963	3·399564	4·140562	5·033834	21
22	1·54598	1·72157	1·916103	2·369919	2·925261	3·603537	4·430402	5·436540	22
23	1·57690	1·76461	1·973587	2·464716	3·071524	3·819750	4·740530	5·871464	23
24	1·60844	1·80873	2·032794	2·563304	3·225100	4·048935	5·072367	6·341181	24
25	1·64061	1·85394	2·093778	2·665836	3·386355	4·291871	5·427433	6·848475	25
26	1·67342	1·90029	2·156591	2·772470	3·555673	4·549383	5·807353	7·396353	26
27	1·70689	1·94780	2·221289	2·883369	3·733456	4·822346	6·213868	7·988061	27
28	1·74102	1·99650	2·287928	2·998703	3·920129	5·111687	6·648838	8·627106	28
29	1·77584	2·04641	2·356566	3·118651	4·116136	5·418388	7·114257	9·317275	29
30	1·81136	2·09757	2·427262	3·243398	4·321942	5·743491	7·612255	10·062657	30
31	1·84759	2·15001	2·500080	3·373133	4·538039	6·088101	8·145113	10·867669	31
32	1·88454	2·20376	2·575083	3·508059	4·764941	6·453387	8·715271	11·737083	32
33	1·92223	2·25885	2·652335	3·648381	5·003189	6·840590	9·325340	12·676050	33
34	1·96068	2·31532	2·731905	3·794316	5·253348	7·251025	9·978114	13·690134	34
35	1·99989	2·37321	2·813862	3·946089	5·516015	7·686087	10·676581	14·785344	35
36	2·03989	2·43254	2·898278	4·103933	5·791816	8·147252	11·423942	15·968172	36
37	2·08069	2·49335	2·985227	4·268090	6·081407	8·636087	12·223618	17·245626	37
38	2·12230	2·55568	3·074783	4·438813	6·385477	9·154252	13·079271	18·625276	38
39	2·16474	2·61957	3·167027	4·616366	6·704751	9·703507	13·994820	20·115298	39
40	2·20804	2·68506	3·262038	4·801021	7·039989	10·285718	14·974458	21·724522	40
41	2·25220	2·75219	3·359899	4·993061	7·391988	10·902861	16·022670	23·462483	41
42	2·29724	2·82100	3·460696	5·192784	7·761588	11·557033	17·144257	25·339482	42
43	2·34319	2·89152	3·564517	5·400495	8·149667	12·250455	18·344355	27·366640	43
44	2·39005	2·96381	3·671452	5·616515	8·557150	12·985482	19·628460	29·555972	44
45	2·43785	3·03790	3·781596	5·841176	8·985008	13·764611	21·002452	31·920449	45
46	2·48661	3·11385	3·895044	6·074823	9·434258	14·590487	22·472623	34·474085	46
47	2·53634	3·19170	4·011895	6·317816	9·905971	15·465917	24·045707	37·232012	47
48	2·58707	3·27149	4·132252	6·570528	10·401270	16·393872	25·728907	40·210573	48
49	2·63881	3·35328	4·256219	6·833349	10·921333	17·377504	27·529930	43·427419	49
50	2·69159	3·43711	4·383906	7·106683	11·467400	18·420154	29·457025	46·901613	50

TABLE IV.

Showing the Amount to which One Pound *per Annum* will increase at Compound Interest in any Number of Years not exceeding 50.

(No. 9——12.)

Years.	2 per Cent.	2½ per Cent.	3 per Cent.	4 per Cent.	5 per Cent.	6 per Cent.	7 per Cent.	Years.
1	1·0000	1·0000	1·000000	1·000000	1·000000	1·000000	1·000000	1
2	2·0200	2·0250	2·030000	2·040000	2·050000	2·060000	2·070000	2
3	3·0604	3·0756	3·090900	3·121600	3·152500	3·183600	3·214900	3
4	4·1216	4·1525	4·183627	4·246464	4·310125	4·374616	4·439943	4
5	5·2040	5·2563	5·309136	5·416323	5·525631	5·637093	5·750739	5
6	6·3081	6·3877	6·468410	6·632975	6·801913	6·975319	7·153291	6
7	7·4343	7·5474	7·662462	7·898294	8·142008	8·393838	8·654021	7
8	8·5830	8·7361	8·892336	9·214226	9·549109	9·897468	10·259803	8
9	9·7546	9·9545	10·159106	10·582795	11·026564	11·491316	11·977989	9
10	10·9497	11·2034	11·463879	12·006107	12·577893	13·180795	13·816448	10
11	12·1687	12·4835	12·807796	13·486351	14·206787	14·971643	15·783599	11
12	13·4121	13·7956	14·192030	15·025805	15·917127	16·869941	17·888451	12
13	14·6803	15·1404	15·617790	16·626838	17·712983	18·882138	20·140643	13
14	15·9739	16·5190	17·086324	18·291911	19·598632	21·015066	22·550488	14
15	17·2934	17·9319	18·598914	20·023588	21·578564	23·275970	25·129022	15
16	18·6393	19·3802	20·156881	21·824531	23·657492	25·672528	27·888054	16
17	20·0121	20·8647	21·761588	23·697512	25·840366	28·212880	30·840217	17
18	21·4123	22·3863	23·414435	25·645413	28·132385	30·905653	33·999033	18
19	22·8406	23·9460	25·116868	27·671229	30·539004	33·759992	37·378965	19
20	24·2974	25·5447	26·870374	29·778079	33·065954	36·785591	40·995492	20
21	25·7833	27·1833	28·676486	31·969202	35·719252	39·992727	44·865177	21
22	27·2990	28·8629	30·536780	34·247970	38·505214	43·392290	49·005739	22
23	28·8450	30·5844	32·452884	36·617889	41·430475	46·995828	53·436141	23
24	30·4219	32·3490	34·426470	39·082604	44·501999	50·815577	58·176671	24
25	32·0303	34·1578	36·459264	41·645908	47·727099	54·864512	63·249038	25
26	33·6709	36·0117	38·553042	44·311745	51·113454	59·156383	68·676470	26
27	35·3443	37·9120	40·709634	47·084214	54·669126	63·705766	74·483823	27
28	37·0512	39·8598	42·930923	49·967583	58·402583	68·528112	80·697691	28
29	38·7922	41·8563	45·218850	52·966286	62·322712	73·639798	87·346529	29
30	40·5681	43·9027	47·575416	56·084938	66·438848	79·058186	94·460786	30
31	42·3794	46·0003	50·002678	59·328335	70·760790	84·801677	102·073041	31
32	44·2270	48·1503	52·502759	62·701469	75·298829	90·889778	110·218154	32
33	46·1116	50·3540	55·077841	66·209527	80·063771	97·343165	118·933425	33
34	48·0338	52·6129	57·730177	69·857909	85·066959	104·183755	128·258765	34
35	49·9945	54·9282	60·462082	73·652225	90·320307	111·434780	138·236878	35
36	51·9944	57·3014	63·275944	77·598314	95·836323	119·120867	148·913460	36
37	54·0343	59·7339	66·174223	81·702246	101·628139	127·268119	160·337402	37
38	56·1149	62·2273	69·159449	85·970336	107·709546	135·904206	172·561020	38
39	58·2372	64·7830	72·234233	90·409150	114·095023	145·058458	185·640292	39
40	60·4020	67·4026	75·401260	95·025516	120·799774	154·761966	199·635112	40
41	62·6100	70·0876	78·663298	99·826536	127·839763	165·047684	214·609570	41
42	64·8622	72·8398	82·023196	104·819598	135·231751	175·950545	230·632240	42
43	67·1595	75·6608	85·483892	110·012382	142·993339	187·507577	247·776496	43
44	69·5027	78·5523	89·048409	115·412877	151·143006	199·758032	266·120851	44
45	71·8927	81·5161	92·719861	121·029392	159·700156	212·743514	285·749311	45
46	74·3306	84·5540	96·501457	126·870568	168·685164	226·508125	306·751763	46
47	76·8172	87·6679	100·396501	132·945390	178·119422	241·098612	329·224386	47
48	79·3535	90·8596	104·408396	139·263206	188·025393	256·564529	353·270093	48
49	81·9406	94·1311	108·540648	145·833734	198·426663	272·958401	378·999000	49
50	84·5794	97·4843	112·796867	152·667084	209·347996	290·335905	406·528929	50

TABLE V.

Exhibiting the Law of Mortality at *Carlisle*. (No. 32.)

Age.	Number who complete that Age.	Number who die in the next interval.	Age.	Number who complete that Year.	Number who die in their next Year.	Age.	Number who complete that Year.	Number who die in their next Year.
0	10000	533	32	5528	56	69	2525	124
1 Month	9467	154	33	5472	55	70	2401	124
2 Months	9313	87	34	5417	55	71	2277	134
3	9226	256	35	5362	55	72	2143	146
6	8970	255	36	5307	56	73	1997	156
9	8715	254	37	5251	57	74	1841	166
1 Year	8461	682	38	5194	58	75	1675	160
2 Years	7779	505	39	5136	61	76	1515	156
3	7274	276	40	5075	66	77	1359	146
4	6998	201	41	5009	69	78	1213	132
5	6797	121	42	4940	71	79	1081	128
6	6676	82	43	4869	71	80	953	116
7	6594	58	44	4798	71	81	837	112
8	6536	43	45	4727	70	82	725	102
9	6493	33	46	4657	69	83	623	94
10	6460	29	47	4588	67	84	529	84
11	6431	31	48	4521	63	85	445	78
12	6400	32	49	4458	61	86	367	71
13	6368	33	50	4397	59	87	296	64
14	6335	35	51	4338	62	88	232	51
15	6300	39	52	4276	65	89	181	39
16	6261	42	53	4211	68	90	142	37
17	6219	43	54	4143	70	91	105	30
18	6176	43	55	4073	73	92	75	21
19	6133	43	56	4000	76	93	54	14
20	6090	43	57	3924	82	94	40	10
21	6047	42	58	3842	93	95	30	7
22	6005	42	59	3749	106	96	23	5
23	5963	42	60	3643	122	97	18	4
24	5921	42	61	3521	126	98	14	3
25	5879	43	62	3395	127	99	11	2
26	5836	43	63	3268	125	100	9	2
27	5793	45	64	3143	125	101	7	2
28	5748	50	65	3018	124	102	5	2
29	5698	56	66	2894	123	103	3	2
30	5642	57	67	2771	123	104	1	1
31	5585	57	68	2648	123			

TABLE VI.

Showing the Value of an Annuity on a Single Life at every Age, according to the Carlisle Table of Mortality, when the Rate of Interest is *Five per Cent.* (No. 65.)

Age.	Value.	Age.	Value.	Age.	Value.	Age.	Value.	Age.	Value.	Age.	Value.
0	12·083	18	15·987	35	14·127	52	11·154	69	6·643	86	2·830
1	13·995	19	15·904	36	13·987	53	10·892	70	6·336	87	2·685
2	14·983	20	15·817	37	13·843	54	10·624	71	6·015	88	2·597
3	15·824	21	15·726	38	13·695	55	10·347	72	5·711	89	2·495
4	16·271	22	15·628	39	13·542	56	10·063	73	5·435	90	2·339
5	16·590	23	15·525	40	13·390	57	9·771	74	5·190	91	2·321
6	16·735	24	15·417	41	13·245	58	9·478	75	4·989	92	2·412
7	16·790	25	15·303	42	13·101	59	9·199	76	4·792	93	2·518
8	16·786	26	15·187	43	12·957	60	8·940	77	4·609	94	2·569
9	16·742	27	15·065	44	12·806	61	8·712	78	4·422	95	2·596
10	16·669	28	14·942	45	12·648	62	8·487	79	4·210	96	2·555
11	16·581	29	14·827	46	12·480	63	8·258	80	4·015	97	2·428
12	16·494	30	14·723	47	12·301	64	8·016	81	3·799	98	2·278
13	16·406	31	14·617	48	12·107	65	7·765	82	3·606	99	2·045
14	16·316	32	14·506	49	11·892	66	7·503	83	3·406	100	1·624
15	16·227	33	14·387	50	11·660	67	7·227	84	3·211	101	1·192
16	16·144	34	14·260	51	11·410	68	6·941	85	3·009	102	0·753
17	16·066									103	0·317

TABLE VII.

Showing the Value of an Annuity on the Joint Continuance of Two Lives according to the Carlisle Table of Mortality, when the difference of their ages is five years, and the Rate of Interest *Five per Cent.* (No. 65.)

Ages.	Value.	Ages.	Value.	Ages.	Value.	Ages.	Value.	Ages.	Value.
0 & 5	10·551	20 & 25	13·398	40 & 45	10·598	59 & 64	6·127	79 & 84	2·045
1 & 6	12·331	21 & 26	13·272	41 & 46	10·444	60 & 65	5·895	80 & 85	1·895
2 & 7	13·258	22 & 27	13·137	42 & 47	10·287	61 & 66	5·678	81 & 86	1·747
3 & 8	14·019	23 & 28	13·000	43 & 48	10·121	62 & 67	5·458	82 & 87	1·626
4 & 9	14·402	24 & 29	12·867	44 & 49	9·937	63 & 68	5·230	83 & 88	1·535
5 & 10	14·649	25 & 30	12·742	45 & 50	9·737	64 & 69	4·988	84 & 89	1·433
6 & 11	14·731	26 & 31	12·615	46 & 51	9·519	65 & 70	4·737	85 & 90	1·279
7 & 12	14·736	27 & 32	12·482	47 & 52	9·292	66 & 71	4·469	86 & 91	1·203
8 & 13	14·689	28 & 33	12·344	48 & 53	9·054	67 & 72	4·207	87 & 92	1·192
9 & 14	14·606	29 & 34	12·208	49 & 54	8·799	68 & 73	3·961	88 & 93	1·219
10 & 15	14·500	30 & 35	12·078	50 & 55	8·528	69 & 74	3·731	89 & 94	1·214
11 & 16	14·389	31 & 36	11·944	51 & 56	8·242	70 & 75	3·528	90 & 95	1·167
12 & 17	14·284	32 & 37	11·806	52 & 57	7·950	71 & 76	3·319	91 & 96	1·161
13 & 18	14·178	33 & 38	11·661	53 & 58	7·657	72 & 77	3·127	92 & 97	1·181
14 & 19	14·069	34 & 39	11·508	54 & 59	7·375	73 & 78	2·948	93 & 98	1·215
15 & 20	13·959	35 & 40	11·354	55 & 60	7·106	74 & 79	2·767	94 & 99	1·191
16 & 21	13·853	36 & 41	11·204	56 & 61	6·860	75 & 80	2·623	95 & 100	1·038
17 & 22	13·746	37 & 42	11·056	57 & 62	6·615	76 & 81	2·467	96 & 101	0·828
18 & 23	13·636	38 & 43	10·907	58 & 63	6·370	77 & 82	2·333	97 & 102	0·555
19 & 24	13·520	39 & 44	10·753			78 & 83	2·194	98 & 103	0·249

TABLE VIII.

Showing the Value of an Annuity on the Joint Continuance of Two Lives according to the Carlisle Table of Mortality, when the difference of their Ages is ten years, and the Rate of Interest *Five per Cent.* (No. 65.)

Ages.	Value.	Ages.	Value.	Ages.	Value.	Ages.	Value.	Ages.	Value.
0 & 10	10·649	19 & 29	13·117	38 & 48	10·396	56 & 66	6·156	75 & 85	2·100
1 & 11	12·275	20 & 30	13·008	39 & 49	10·195	57 & 67	5·881	76 & 86	1·956
2 & 12	13·087	21 & 31	12·896	40 & 50	9·984	58 & 68	5·600	77 & 87	1·838
3 & 13	13·769	22 & 32	12·776	41 & 51	9·766	59 & 69	5·319	78 & 88	1·759
4 & 14	14·106	23 & 33	12·648	42 & 52	9·548	60 & 70	5·044	79 & 89	1·657
5 & 15	14·334	24 & 34	12·510	43 & 53	9·329	61 & 71	4·779	80 & 90	1·515
6 & 16	14·419	25 & 35	12·365	44 & 54	9·104	62 & 72	4·529	81 & 91	1·450
7 & 17	14·432	26 & 36	12·214	45 & 55	8·870	63 & 73	4·302	82 & 92	1·460
8 & 18	14·395	27 & 37	12·058	46 & 56	8·626	64 & 74	4·094	83 & 93	1·479
9 & 19	14·321	28 & 38	11·900	47 & 57	8·372	65 & 75	3·921	84 & 94	1·468
10 & 20	14·221	29 & 39	11·747	48 & 58	8·111	66 & 76	3·746	85 & 95	1·443
11 & 21	14·106	30 & 40	11·607	49 & 59	7·851	67 & 77	3·580	86 & 96	1·397
12 & 22	13·987	31 & 41	11·474	50 & 60	7·601	68 & 78	3·407	87 & 97	1·324
13 & 23	13·864	32 & 42	11·342	51 & 61	7·370	69 & 79	3·210	88 & 98	1·280
14 & 24	13·737	33 & 43	11·207	52 & 62	7·142	70 & 80	3·020	89 & 99	1·192
15 & 25	13·608	34 & 44	11·063	53 & 63	6·911	71 & 81	2·807	90 & 100	0·950
16 & 26	13·483	35 & 45	10·912	54 & 64	6·669	72 & 82	2·616	91 & 101	0·733
17 & 27	13·359	36 & 46	10·750	55 & 65	6·418	73 & 83	2·430	92 & 102	0·508
18 & 28	13·235	37 & 47	10·579			74 & 84	2·260	93 & 103	0·235

Annuities, Borrowing upon. See Debt, *National.*

ANNULAR, in a general sense, something in the form of, or resembling a ring. It is also a peculiar denomination of the fourth finger, commonly called the *ring finger.*

ANNULET, a little circle, borne as a charge in coats of arms, as also added to them as a *difference.* Among the Romans it represented liberty and nobility. It also denotes strength and eternity, by reason of its circular form.

ANNULOSA (from *annulus*, a ring or segment), a term in zoology applied by naturalists to a great division of the animal kingdom. It contains five classes, viz. Crustacea, Myriopoda, Arachnides, Insecta, and Vermes. These classes will be treated of separately in this work, as explained under the words Animal Kingdom. See the concluding part of that article.

ANNUNCIADA, Annuntiada, or Annunciata, an order of knighthood in Savoy, first instituted by Amadeus I. in the year 1409. Their collar was of 15 links, interwoven one with another, in form of a true lover's knot; and the motto F. E. R. T., signifying *Fortitudo ejus Rhodum tenuit.* Amadeus VIII. gave the name *Annunciada* to this order, which was formerly known by that of *the knot of love;* changing at the same time the image of St Maurice, patron of Savoy, which hung at the collar, for that of the Virgin Mary; and, instead of the motto above mentioned, substituting the words of the angel's salutation.

ANNUNCIATION, the tidings brought by the angel Gabriel to the Virgin Mary, of the incarnation of Christ. —Annunciation is also a festival kept by the church on the 25th of March, in commemoration of these tidings. This festival appears to be of very great antiquity. There is mention made of it in a sermon which goes under the name of Athanasius. Others carry it up to the time of Gregory Thaumaturgus, because there is a sermon likewise attributed to him upon the same subject. But the best critics reject both these writings as spurious. However, it is certain that this festival was observed before the time of the council of Trullo, in which there is a canon forbidding the celebration of all festivals in Lent, excepting the Lord's day and the feast of the annunciation; so that we may date its original from the 7th century. In the Romish church, on this feast, the pope performs the ceremony of marrying or cloistering a certain number of maidens, who are presented to him in the church, clothed in white serge, and muffled up from head to foot: an officer stands by, with purses containing notes of 50 crowns for those who make choice of marriage, and notes of 100 for those who choose to veil.

Annunciation is likewise a title given by the Jews to a part of the ceremony of the passover.

ANODYNE (from α privative, and οδυναω, *doleo;* or α negative, and οδυνη, *pain*), a term applied to medicines which ease pain and procure sleep.

ANOINTERS, a religious sect in some parts of England, so called from the ceremony they used of anointing all persons before they admitted them into their church. This ceremony they founded upon James v. 14, 15.

ANOLYMPIADES, in *Antiquity*, a name given by the Elians to those Olympic games which had been celebrated under the direction of the Pisæans and Arcadians. The Elians claimed the sole right of managing the Olympic games, in which they sometimes met with competitors. The hundred and fourth Olympiad was celebrated by order of the Arcadians, by whom the Elians were at that time reduced very low. This, as well as those managed by the inhabitants of Pisa, they called ανολυμπιαδας, that is, unlawful Olympiads; and left them out of their annals, wherein the names of their victors and remarkable occurrences were registered.

ANOMALISTICAL Year, in *Astronomy*, the time that the earth takes to pass through her orbit: it is also called the *Periodical Year.* The space of time belonging to this year is greater than the tropical year, on account of the precession of the equinoxes. Anomalistical || Anotta.

ANOMALOUS, a term applied to whatever is irregular, or deviates from the rule observed by other things of the like nature.

Anomalous Verbs, in *Grammar*, such as are not conjugated conformably to the paradigm of their conjugation. They are found in all languages. In Latin, the verb *lego* is the paradigm of the third conjugation, and runs thus, *lego, legis, legit:* by the same rule it should be *fero, feris, ferit;* but we say, *fero, fers, fert: fero*, then, is an anomalous verb. In English the irregularity relates often to the preter tense and passive participle; for example, *give*, were it formed according to rule, would make *gived* in the preter tense and passive participle; whereas, in the former, it makes *gave*, and in the latter *given.*

ANOMALY, in *Astronomy*, an irregularity in the motions of the planets, whereby they deviate from the aphelion or apogee.

ANOMŒANS, in *Ecclesiastical History*, the name by which the pure Arians were called in the 4th century, in contradistinction to the Semi-Arians. The word is derived from the Greek ανομοιος, *different, dissimilar:* for the pure Arians asserted that the Son was of a nature different from, and in nothing like, that of the Father; whereas the Semi-Arians acknowledged a likeness of nature in the Son, at the same time that they denied, with the pure Arians, the consubstantiality of the Word. The Semi-Arians condemned the Anomœans in the council of Seleucia; and the Anomœans in their turn condemned the Semi-Arians in the councils of Constantinople and Antioch, erasing the word ομοιος, *like*, out of the formula of Rimini and that of Constantinople.

ANOMORHOMBOIDIA, in *Natural History*, the name of a genus of spars. The word is derived from the Greek ανωμαλης, *irregular*, and ρομβοειδης, a *rhomboidal* figure. The bodies of this genus are pellucid, crystalline spars, of no determinate or regular external form, but always breaking into regularly rhomboidal masses; easily fissile, and composed of plates running both horizontally and perpendicularly through the masses, but cleaving more readily and evenly in a horizontal than in a perpendicular direction, the plates being ever composed of irregular arrangements of rhomboidal concretions.

ANONYMOUS, something that is nameless, or of which the name is concealed. It is a term equally applied to books which do not express the author's name, or to authors whose names are unknown. See Bibliography.

ANOREXIA, Anorexy (from α negative, and ορεξις, *appetite*), a want of appetite, or a loathing of food.

ANOSSI, a province of the island of Madagascar, lying between lat. 23. 18. and 26. 0. S. See Madagascar.

ANOTTA, or Arnotta, in dyeing, an elegant red colour, formed from the pellicles or pulp of the seeds of the bixa, a tree common in South America. It is also called *Terra Orleana*, and *Roucou.*

The manner of making anotta is as follows: The red seeds, cleared from the pods, are steeped in water for seven or eight days, or longer, till the liquor begins to ferment; then strongly stirred, stamped with wooden paddles and beaters, to promote the separation of the red skins: this process is repeated several times, till the seeds are left white. The liquor, passed through close cane sieves, is pretty thick, of a deep red colour, and an offensive smell; in boiling, it throws up its colouring matter to the surface in form of scum, which is afterwards boiled down by itself

Anout || Anquetil.

to a due consistence, and made up while soft into balls. The anotta commonly met with among us is moderately hard and dry, of a brown colour on the outside, and a dull red within. It is difficultly acted upon by water, and tinges the liquor only of a pale brownish yellow colour. It very readily dissolves in rectified spirit of wine, and communicates a high orange or yellowish red. Hence it is used as an ingredient in varnishes, for giving more or less of an orange cast to the simple yellows. Alkaline salts render it perfectly soluble in boiling water, without altering its colour. Wool or silk boiled in the solution acquires a deep, but not a very durable, orange dye. Its colour is not changed by alum or by acids, any more than by alkalies; but when imbibed in cloth, it is discharged by soap, and destroyed by exposure to the air. It is said to be an antidote to the poisonous juice of manioc or cassava.

ANOUT, a small island in the Schagerrack, or that part of the sea of Denmark which has Norway on the north, Jutland on the west, and the isle of Zealand on the south. It lies in long. 13. 0. E. and lat. 56. 36. N.

ANQUETIL, Lewis Peter, a French historian, was born at Paris on the 21st of January 1723. At the age of 17 he entered the congregation of St Genevieve, where he taught theology and literature with ability and success. He afterwards became director of the academy at Rheims; and, in 1759, he was appointed prior of the abbey de la Roe, in Anjou. Soon after this he was sent, in the capacity of director, to the college of Senlis. In 1766 he obtained the curacy or priory of Chateau-Renard, near Montargis, which he exchanged, at the commencement of the Revolution, for the curacy of La Villette, in the neighbourhood of Paris. During the reign of terror he was imprisoned at St Lazare. On the establishment of the National Institute, he was elected a member of the second class, and was soon afterwards employed in the office of the minister for foreign affairs. Endowed with a robust constitution, which was preserved by a natural equality of temper, and general moderation in diet, Anquetil was capable of very laborious exertions, and is said to have passed ten hours every day regularly in study. When upwards of eighty he still meditated extensive literary undertakings; but he was carried off by death, in the midst of his projects and researches, on the 6th of September 1808, in the 86th year of his age. On the evening previous to this event, he is reported to have said to one of his friends, "Come and see a man who is dying full of life."

As an author, M. Anquetil does not stand very high in the ranks of literature. He possessed more industry in research than ability or judgment in execution. His style is censurable in many respects, and he appears to have been almost entirely destitute of the critical discernment and philosophical sagacity which are requisite to form the character of a good historian. The following is a list of his principal works.

1. *Histoire Civile et Politique de la Ville de Reims.* 1756–57, 3 vols. 12mo. The history is brought no farther down than 1657: a fourth volume should have been added, but it never appeared. Anquetil is said to have written this work in concert with one Felix de la Salle, and it is, perhaps, the best of all his productions. 2. *Almanach de Reims.* 1754, 24to 3. *L'Esprit de la Ligue, ou Histoire Politique des Troubles de France pendant les* 16 *et* 17 *siècles.* 1767, 3 vols. 12mo. This work has been frequently reprinted. 4. *Intrigue du Cabinet sous Henri IV. et sous Louis XIII. terminée par la Fronde.* 1780, 4 vols. 12mo. 5. *Louis XIV. sa Cour et le Régent.* 1789, 4 vols. 12mo; reprinted in 1794, 5 vols. 12mo. 6. *Vie du Maréchal de Villars, écrite par lui-même, suivie du Journal de la Cour de* 1724 *à* 1734. Paris, 1787, 4 vols. 12mo; reprinted in 1792. 7. *Précis de l'Histoire Universelle.* 1797, 9 vols. 12mo; reprinted in 1801 and 1807, in 12 vols. 12mo. This work has been translated into English, Spanish, and Italian. 8. *Motifs des Guerres et des Traités de Paix de la France pendant les règnes de Louis XIV., Louis XV., et Louis XVI.* 1798, 8vo. 9. *Histoire de France depuis les Gaules jusqu'à la fin de la Monarchie.* 1805 et *seqq.* 14 vols. 12mo. This work was composed in haste, and is of no great value. 10. *Notice sur la Vie de M. Anquetil du Perron.* M. Anquetil likewise wrote several papers in the Memoirs of the Institute. See *Biographie Universelle.* (K.)

ANQUETIL DU PERRON (Abraham Hyacinth), brother of the subject of the preceding article, was born at Paris on the 7th of December 1731. Having distinguished himself as a student at the university of that city, and acquired a considerable knowledge of the Hebrew language, he was invited to Auxerre by M. de Caylus, then the bishop of that diocese. This prelate made him study theology, first at the academy of his diocese, and afterwards at that of Amersfort, near Utrecht; but Anquetil had no desire to embrace the ecclesiastical vocation, and devoted himself with ardour to the study of the different dialects of the Hebrew, and of the Arabic and Persian. Neither the solicitations of M. de Caylus, nor the hopes of rapid preferment, had the power to detain him at Amersfort after he thought he had acquired every thing that was to be learnt there. He returned to Paris, where his diligent attendance at the Royal Library, and his ardour in the prosecution of his favourite studies, attracted the attention of the Abbé Sallier, keeper of the manuscripts, who introduced him to the acquaintance of his associates and friends, whose united exertions procured for him a small salary, as student of the oriental languages. He had scarcely received this appointment, when, having accidentally laid his hands on some manuscripts in the *Zend*, he formed the project of a voyage to India, with the view of discovering the works of Zoroaster. At this period an expedition was preparing at the port of L'Orient, which was destined for India. M. du Perron, however, applied in vain, through his protectors, for a passage; and seeing no other means of accomplishing his plan, he enlisted as a common soldier, and set out from Paris, with a knapsack on his back, on the 7th of November 1754. His friends procured his discharge; and the minister, affected by this romantic zeal for science, granted him a free passage, a seat at the captain's table, and a salary, the amount of which was to be fixed by the governor of the French settlements in India. After a passage of nine months, Anquetil landed, on the 10th of August 1755, at Pondicherry. Here he remained no longer than was necessary to make himself master of the modern Persian, and then hastened to Chandernagore, where he thought to acquire the Sanscrit. But in this he was deceived; and he was on the point of returning, when a serious complaint threatened his life. He had scarcely escaped from this danger, when war was declared between France and England; Chandernagore was taken; and Anquetil resolved to return to Pondicherry by land. After a journey of one hundred days, in the course of which he encountered many adventures, and suffered many hardships, he arrived at Pondicherry. Here he found one of his brothers who had arrived from France, and embarked with him for Surat; but, with the view of exploring the country, he landed at Mahe, and proceeded on foot. It was at Surat that he succeeded, by perseverance and address in his intercourse with the native priests, in acquiring a sufficient knowledge of the languages to enable him to translate the Dictionary called the *Vedidad-Sade*, and some other works. From thence he proposed going to Benares, to study the languages, antiquities, and sacred laws of

the Hindoos; but the capture of Pondicherry obliged him to return to France. He accordingly embarked on board an English vessel, and landed at Portsmouth in the month of November 1761. After spending some time in London, and visiting Oxford, he set out for Paris, where he arrived on the 4th of May 1762, without fortune or the desire of acquiring any, but esteeming himself rich in the possession of one hundred and eighty oriental manuscripts, besides other curiosities. The Abbé Barthelemy, and his other friends, procured for him a pension, with the title and appointments of Interpreter for the oriental languages at the royal library. In 1763 the Academy of the *Belles Lettres* received him among the number of its associates; and from that period he devoted himself to the arrangement and publication of the materials he had collected during his eastern travels. In 1771 he published a work in three volumes 4to, under the title of *Zend-Avesta*, containing collections from the sacred writings of the Persians, among which are fragments of works ascribed to Zoroaster; and he accompanied this work with an account of the life of that sage. This publication must be considered as constituting a very important accession to our stores of oriental literature. A recent historian, and very competent judge, refers to the *Zend-Avesta*, as certainly the most authentic source from which we can derive information regarding the religion and institutions of the great Persian legislator. (Sir John Malcolm's *Hist. of Persia*, vol. i. p. 193, note.) To the *Zend-Avesta* M. du Perron prefixed a discourse, in which he treated the university of Oxford, and some of its learned members, with ridicule and disrespect. Mr (afterwards Sir William) Jones replied to these invectives in an anonymous letter, addressed to the author, written in French, with uncommon force and correctness of style, but at the same time with a degree of asperity which could only be justified by the petulance of M. du Perron. In 1778 he published his *Législation Orientale*, in 4to, a work in which he controverts the system of Montesquieu, and endeavours to prove that the nature of oriental despotism has been misrepresented by most authors; that in the empires of Turkey, Persia, and Hindostan, there are codes of written law which equally bind the prince and subject; and that in these three empires the inhabitants possess both movable and immovable property, which they enjoy with perfect security. His *Recherches Historiques et Géographiques sur l'Inde* appeared in 1786, and formed part of Thieffenthaler's *Geography of India*. They were followed in 1789 by his treatise *De la Dignité du Commerce et de l'Etat du Commerçant*. The Revolution seems to have greatly affected him. During that period he abandoned society, shut himself up in his study, and devoted himself entirely to literary seclusion. In 1798 he published *L'Inde en Rapport avec l'Europe*, &c. in 2 vols. 8vo; a work which is more remarkable for its virulent invectives against the English, and for its numerous misrepresentations, than for the information which it contains, or the soundness of the reflections which it conveys. The spirit of the work, indeed, may be ascertained from the summary of its contents stated in the title-page, in which the author professes to give a detailed, accurate, and terrific picture of the English Machiavelism in India; and he addresses his work in a ranting bombastic dedication to the *Manes* of Dupleix and Labourdonnais. In 1804 he published a Latin translation from the Persian of the *Oupnek'hat* or *Upanischada*, *i. e.* Secrets which must not be revealed, in 2 vols. 4to. On the re-organization of the Institute, M. Anquetil was elected a member, but soon afterwards gave in his resignation. He died at Paris on the 17th of January 1805.

Besides the works we have already enumerated, M. Anquetil read to the academy several memoirs on subjects connected with the history and antiquities of the East. At the time of his death he was engaged in revising a translation of the *Travels of Father Paulin de St Barthelemy in India*, which work was continued by M. Silvestre de Sacy, and published in 1808, in 3 vols. 8vo. He also left behind him a great number of manuscripts, among which his biographers particularly notice the translation of a Latin treatise *on the Church*, by Doctor Legros, in 4 vols. 4to.

From the preceding narrative our readers will be enabled to form some notion of the character of Anquetil du Perron. Among his countrymen he is regarded as one of the most learned men of the 18th century. He certainly distinguished himself by a very ardent and disinterested zeal in the prosecution of those studies to which he dedicated the labours of a long life; but the lustre of his literary character was obscured by a very absurd vanity, and the most inveterate prejudices. In a Discourse addressed to the Asiatic Society at Calcutta, in 1789, Sir William Jones speaks of him as "having had the merit of undertaking a voyage to India, in his earliest youth, with no other view than to recover the writings of Zeratust (Zoroaster), and who would have acquired a brilliant reputation in France, if he had not sullied it by his immoderate vanity and virulence of temper, which alienated the good-will even of his own countrymen." In the same Discourse he affirms that M. Anquetil most certainly had no knowledge of the Sanscrit.—See *Biographie Universelle; Monthly Review*, vol. lxi.; Lord Teignmouth's *Life of Sir William Jones*. (K.)

ANSÆ, in *Astronomy*, implies the parts of Saturn's ring projecting beyond the disk of the planet. The word is Latin, and properly signifies *handles;* these parts of the ring appearing like handles to the body of the planet.

ANSARIANS, a people of Syria, so called in the country, but styled in Delisle's maps *Ensarians*, and in those of D'Anville *Nassaris*. The territory occupied by the Ansarians is that chain of mountains which extends from Antakia to the rivulet called *Nahr-el-Kabir*, or the Great River. They are divided into several tribes or sects, among which are distinguished the Shamsia, or adorers of the sun; the Kelbia, or worshippers of the dog; and the Kadmousia, who are said to pay a particular homage to that part in women which corresponds to the priapus.

ANSBACH, a bailiwick in the circle of Rezat, in the kingdom of Bavaria, extending over 124 square miles, or 79,360 acres, with 2 market-towns and 79 villages. It is an undulating plain, watered by the rivers Rezat, Zenn, and Bidert. It contains 11,800 inhabitants, who draw from its fruitful soil excellent corn and tobacco, and keep many horses and cattle. There is an alabaster and a gypsum quarry worked in the bailiwick. The capital, of the same name, is about 30 miles south-west of Nuremberg, and contains 950 inhabitants.

ANSE, an ancient town of France, in the Lyonnois, on the river Saone. It is the head of a canton in the department of the Rhone, and formerly bore the title of barony. Population 1640. 13½ miles north of Lyons. Long. 6. 55. W. Lat. 45. 55. N.

ANSELM, archbishop of Canterbury, in the reigns of William Rufus and Henry I. He was born in the year 1033, at Aost, a town in Savoy, at the foot of the Alps. He became a monk in the abbey of Bec in Normandy, of which he was afterwards chosen prior, and then abbot. In the year 1092 he was invited over to England by Hugh earl of Chester; and in the year following was prevailed on, as we are told, with great difficulty, to accept the archbishopric of Canterbury. He enjoined celibacy on the

clergy, for which he was banished by King Rufus; but he was recalled by Henry on his coming to the crown. In conformity to Pope Urban's decree, he refused to consecrate such bishops as were invested by the king, denying it to be the royal prerogative: for this he was banished again, till, the pope and king agreeing, he was recalled in 1107. In short, from the day of his consecration to that of his death, he was continually employed in defending the prerogative of the church against the encroachments of the crown; and for that purpose spent much of his time in travelling backwards and forwards between England and Rome, for the advice and direction of his holiness. At the council of Bari, in the kingdom of Naples, the pope being puzzled by the arguments of the Greeks against the Holy Ghost's proceeding from the Father, called upon Anselm, who was present, and discussed their objections with great applause. Priests call him a resolute saint; to other people he appears to have been an obstinate and insolent priest. He wrought many miracles, if we may believe the author of his life, both before and after his death, which happened at Canterbury in the 76th year of his age, anno 1109. He was canonized in the reign of Henry VII. Anselm, though we may disregard him as a saint, deserves to be remembered as one of the principal revivers of literature, after three centuries of profound ignorance. His works have been often reprinted. The best edition is that of Father Gerberon, printed at Paris in 1675, in 2 vols. folio.

ANSIKO, a kingdom in the interior of western Africa, bounded on the west by the river Umbre, which runs into the Zaire, the kingdom of Wangua, and the Amboes, who border on Loango; and on the south by Songo and Sunda, provinces of Congo. It contains a great variety of wild beasts, as lions, rhinoceroses, &c. and many copper-mines. The king of Ansiko, or the great Micoco, is said to command thirteen kingdoms, and is esteemed the most powerful monarch in this part of Africa. Our knowledge of the country, however, is very imperfect, being derived solely from the hearsay reports of Lopez and Merolla, who visited Congo in the 16th century. According to them, the people are brave, swift, active, but savage and cruel in the most frightful degree, human flesh being not only eaten, but openly sold in the markets, and the subjects offering themselves to the sovereign for the gratification of his palate. These reports, which are not very credible, are contrasted with others that represent them as an industrious people, manufacturing cloths from the fibres of the palm-tree, and carrying on an extensive trade both with Congo and interior Africa. Their language is barbarous, and difficult to be learned, even by the inhabitants of Congo. The most distinguished among them wear red and black caps of Portuguese velvet; the lower ranks go naked from the waist upwards; and, to preserve their health, anoint their bodies with a composition of pounded sandal-wood and palm-oil. Their arms are battle-axes, and small but very strong bows, adorned with serpents' skins. Their strings are made of pliant and tender shoots of trees, that will not break; and their arrows of hard and light wood. They kill birds flying, and shoot with surprising swiftness. With equal dexterity they manage their battle-axes, one end of which is sharpened and cuts like a wedge, while the other is flattened like a mallet, with a handle set between, about half the length of the iron, rounded at the end like an apple, and covered with the skin of a serpent. The current money in this country is the zimbis or shell, which passes among several African nations. They worship the sun as their chief deity, representing him by a male figure, and the moon by a female. They have also an infinite number of inferior deities, each individual having a particular idol. They seem on the whole to be a people respecting whom it might be desirable to obtain further and more recent information.

ANSLO, a seaport town of Norway, in the province of Aggerhuus, with a bishop's see. The supreme court of justice is held here for Norway. It is seated on a bay of the same name. Long. 10. 14. E. Lat. 50. 24. N.

ANSON, George, a gentleman whose merit and good fortune as a naval commander exalted him to the rank of nobility. He was the son of William Anson, Esq. of Huckborough, in Staffordshire; and, showing an early inclination for the sea, received a suitable education. The first command he enjoyed was that of the Weasel sloop in 1722; but the most memorable action of his life, and the foundation of his future good fortune, took place on his receiving the command of five ships, a sloop, and two victuallers, equipped to annoy the Spaniards in the South Seas, and to co-operate with Admiral Vernon across the Isthmus of Darien; an expedition the principal object of which failed by the unaccountable delay in fitting him out. He sailed, however, in September 1740; doubled Cape Horn in a dangerous season; lost most of his men by the scurvy; and with only one remaining ship, the Centurion, crossed the great Pacific Ocean. If no considerable national advantage resulted from this voyage, Commodore Anson made his own fortune, and enriched his surviving companions, by the capture of a rich galleon on her passage from Acapulco to Manilla, with which he returned home round the Cape of Good Hope. If he was lucky in meeting this galleon, he was no less fortunate in escaping a French fleet then cruising in the Channel, by sailing through it during a fog. He arrived at Spithead in June 1744. In a short time after his return he was appointed rear-admiral of the blue, and one of the lords of the admiralty. In April 1745 he was made rear-admiral of the white, and the following year vice-admiral of the blue, at which time he was chosen to represent the borough of Heydon in parliament. In 1747, being on board the Prince George of 90 guns, in company with Admiral Warren and 12 other ships, he intercepted, off Cape Finisterre, a powerful fleet, bound from France to the East and West Indies; when, by his valour and conduct, he again enriched himself and his officers, and at the same time strengthened the British navy, by taking six men of war and four East Indiamen, not one of them escaping. The French admiral, M. Jonquiere, on presenting his sword to the conqueror, said, *Monsieur, vous avez vaincu l'Invincible, et la Gloire vous suit*—"Sir, you have conquered the Invincible, and Glory follows you;" pointing to the ships named the *Invincible* and the *Glory*, which he had taken. For his signal services he was created baron of Soberton in Hants. The same year he was appointed vice-admiral of the red; and, on the death of Sir John Norris, was made vice-admiral of England. In 1748 he was made admiral of the blue: he was afterwards appointed first lord of the admiralty, and was at length made admiral and commander-in-chief of his majesty's fleet, in which rank he continued, with a very short interval, until his death; and the last service he performed was to convey Queen Charlotte to England. He died in June 1762. No performance ever met with a more favourable reception than the account of Anson's voyage round the world. Though it is printed under the name of his chaplain, it was composed under his lordship's own inspection, and from the materials he himself furnished, by Mr Benjamin Robins.

ANSTRUTHER, Easter, a royal borough and parish of Scotland, in the county of Fife. It is situated on the north shore of the Frith of Forth, and possesses an excellent harbour. Population in 1821, 1090. 10 miles S. of St Andrews.

ANSTRUTHER, *Wester*, a parish and small seaport of Scotland, situated near Easter Anstruther, with which, and the towns of Crail, Pittenweem, and Kilrenny, it unites in returning a representative to parliament. The parish includes the Isle of May. There is a weekly packet-boat to Leith; and the steam-boat that plies between Edinburgh and Aberdeen touches at Wester as well as at Easter Anstruther. Population 429. 23 miles north-east of Edinburgh. Long. 2. 44. W. Lat. 56. 12. N.

ANT. The history of a tribe of insects so long celebrated for their industry and frugality, and for the display of that sagacity which characterizes some of the higher orders of animals, is peculiarly calculated to occupy the attention of modern naturalists. The ancients, indeed, had often noticed the habits and economy of the ant; but their accounts, at all times deficient in accuracy from the want of precise definitions and logical arrangement of the objects they describe, are in this instance so mixed up with fanciful notions and chimerical doctrines, and so coloured by the vivid imagination and credulity of the narrators, as to have retarded rather than advanced the progress of real knowledge. Aristotle and Pliny report, for instance, that the labours of ants are in a great measure regulated by the phases of the moon; and the latter mentions a species found in the northern parts of India, whose size was said to equal that of the wolves of Egypt, whose colour was the same as that of a cat, and whose occupation in winter consisted in digging up gold from the bowels of the earth; while the inhabitants in the summer robbed them of their treasures, after having decoyed them, by stratagem, from their nests. Great mistakes have prevailed, even in later times, from the circumstance of the larvæ of ants bearing a resemblance to grains of corn, which it was supposed these insects hoarded up as a provision for winter consumption. The form of the eggs and of the larvæ, and the attention paid to them by the ants, were described by Dr King in the 23d number of the *Philosophical Transactions;* but Leeuwenhoeck was the first who distinguished with precision the different forms which the insect assumes in the several stages of its growth. He traced the successive changes from the egg to the larva, the nymph, and the perfect insect. Swammerdam pursued his scrutiny into these successive developments with greater minuteness; and, unrivalled in the art of microscopic dissection, discovered the wonderful encasement of all the parts of the future ant at every preceding stage, and showed that it appears under such different forms only from the nature of its envelopes, each of which, at the proper period, is in its turn cast off. Linnæus (*Memoirs of the Royal Academy of Sciences at Stockholm*, vol. ii.) ascertained some of the leading facts with regard to the distinction between the sexes, and determined that the ants which are furnished with wings are the only individuals that exercise the sexual functions. Several particulars with regard to the economy of the ants were published by Mr Gould, in a book entitled *An Account of English Ants*, of which an abstract is given in the *Philosophical Transactions* for 1747, by the Rev. Dr Miles. The facts are there stated with tolerable correctness; but some errors have been committed by following too closely the analogy with bees. Geoffroy (*Histoire des Insectes qui se trouvent aux Environs de Paris*), though a good naturalist on other topics, is a bad authority on the subject of ants. The most complete series of observations on the natural history of these insects, is that for which we are indebted to the celebrated Swedish entomologist De Geer (*Mémoires pour servir à l'Histoire des Insectes*), an observer on whose fidelity the most implicit reliance may be placed.

In the *Encyclopédie Méthodique*, under the article *Fourmi*, Olivier has drawn up an able statement of all the material facts that had been established by preceding naturalists; without, however, adding any original observations of his own, excepting the description of five or six undescribed species. A full account of the habits of those ants which for a long period infested the island of Martinique, is contained in some of the earlier numbers of the *Journal de Physique* (vols. ix. and x.) The author of these memoirs, M. Barboteau, has given many curious details on this subject, and has cited a number of facts on various authorities; and the account might now be swelled by the reports of subsequent travellers in different parts of the world; but these statements are often made upon slender authority, and are too much tinctured with the marvellous to admit of much credit being attached to them. The narrative given to us by Bonnet in the second volume of his *Observations sur les Insectes*, of the proceedings of a colony of ants which had established itself in the head of a large thistle, and which he transported into his house, is highly interesting; but it elucidates only a few points of their economy, and leaves us to regret that so patient and indefatigable an observer had not bestowed more of his attention to the study of this tribe of insects. In the *Philosophical Transactions* for 1790 we find an interesting memoir on the sugar-ant, a species which, for a period of ten years, committed dreadful ravages in the sugar plantations throughout the whole island of Grenada. The most methodical account of this tribe of insects that has yet appeared is that of Latreille, in his *Histoire Naturelle des Fourmis*, published at Paris in 1802, a work which alone would have secured the reputation of the author as an able and scientific naturalist. His merit is particularly conspicuous in the clearness and accuracy of his descriptions of each species, and the luminous method of arrangement which he has adopted in their classification. He gives an account of one hundred species which he had himself observed, and of twenty-four which he has described from the reports of others: these he distributes into nine natural families, according to the situation and structure of the antennæ, and the form of the abdominal scales. But the work which contains the most copious collection of facts relative to the habits and economy of ants is that of Mr P. Huber of Geneva, entitled *Traité des Mœurs des Fourmis Indigènes*, published in 1810. By means of an apparatus which he contrived so as to admit of his obtaining a view whenever he pleased of the inmost recesses of their habitation, he was enabled to observe what was going on in the interior of the nest, and to investigate with success some of the most important and interesting features of their history. The results of his researches, as they are reported in his work, are highly curious and instructive, and open a wide field of speculation and inquiry to the philosophical entomologist. They have not only elucidated many obscure points with regard to one tribe of insects, but have disclosed some general views of the instincts and faculties of this order of the creation, which are totally new, and must tend, in a considerable degree, to exalt our conceptions of the inexhaustible powers and resources of nature.

Ant.

Economy and policy of ants.

Having thus pointed out the principal sources of information in this department of entomology, we shall proceed to give an outline of the leading facts that have been ascertained relative to the economy and domestic policy of these remarkable insects.

Functions of the neuters.

In common with many tribes of hymenopterous insects, ants present the remarkable peculiarity of a threefold distinction of sex among the individuals of the same species; a circumstance which is met with in no other order of the animal kingdom, and which appears, as far as observation has extended, to be totally excluded from the plan

Ant. of the vegetable creation. Besides males and females, there exists an apparently intermediate order of *neuters*, which are also denominated labouring or working ants. The neuters, thus exempted from every sexual function, exercise, on the other hand, all the other offices necessary for the existence and welfare of the community to which they belong. It is they who collect supplies of food, who explore the country for this purpose, and seize upon every animal substance, whether living or dead, which they can lay hold of, and transport to their nest. It is they who construct every part of their dwelling-place, who attend to the hatching of the eggs, to the feeding of the larvæ, and to their removal, as occasion may require, to different situations favourable to their growth and development; and who, both as aggressors and as defenders, fight all the battles of the commonwealth, and provide for the safety of their weaker and more passive companions. Thus all the laborious and perilous duties of the state are performed solely by this description of ants, who act the part of helots in these singularly constituted republics of insects. We find, however, on closer examination, that, in all probability, this anomaly in point of sex is more apparent than real; and that, however different in external conformation from the productive females, they nevertheless originally and essentially belong to the same sex. There is every reason to believe that the development of the sexual organs in the former is the consequence of some difference in the circumstances in which the larva is placed during its growth. That such is the case with bees, is now perfectly well established; and the analogy of bees with ants, in many points of physiology, must be admitted as a strong argument in corroboration of this theory. In all the essential features of internal structure, the supposed neuters agree with the female, and differ from the male of the same species. In all hymenopterous insects, which are armed with stings, a difference exists in the two sexes, as to the number of articulations composing the antennæ; those of the female consisting of fewer pieces than those of the male. The accurate observations of Mr Kirby (*Monographia Apum*) have determined that in the bee the antennæ of the male have fifteen articulations, while those of the female and the neuter have only fourteen. In the ant, likewise, we find thirteen articulations in the male, and only twelve in the female; and likewise only twelve in the neuter. In the male ant the abdomen has seven rings, in the female and neuter only six. In the two latter classes the head is broader, and the mandibles very large and powerful compared with those of the male, and are furnished with serrated edges, and a sharp and often hooked point. The external sexual organs of the female and of the neuter are so nearly similar in appearance, that Latreille declares he was unable to perceive the least difference between them. On the other hand, it is to be observed, that in the neuter the principal deviation from the model of the female consists in the absence of wings; a circumstance which, as it regards the organs of locomotion only, is one of subordinate importance in the economy; and their presence may, without difficulty, be conceived to be connected with a certain condition of the sexual organs, as are the horns of the deer, and the beard in the human species. But although of so little consequence in a physiological point of view, it is a circumstance materially affecting their external condition. It dooms them to severe toil and exertion in traversing the ground, and in climbing up the steep paths that may lie in their route; while their more luxurious and favoured associates are fluttering in the spacious realms of air in search of amusement, and wafted to the objects of their gratification on the light breezes of the summer.

Ants appear to be endowed with a greater share of muscular strength than almost any other insect of the same size. Of this we have sufficient proofs in the vivacity of their movements, the incessant toil which many undergo, the great loads which they are seen to carry, often exceeding ten or twelve times their own weight, and the agility which they exert in making their escape from danger. This high degree of irritability is conjoined, apparently, with a corresponding share of the power of sensation; a power which is manifested in their susceptibility to a variety of impressions capable of affecting the organs of sense. They have a quick perception of all changes of temperature, as well as of other conditions of the atmosphere; and are readily and disagreeably affected by moisture. In the perfection of the sense of sight they seem to be nearly on a level with other insects; and the males and females are provided with both the descriptions of eyes peculiar to this class, namely, the composite and the simple eyes. The labouring ants, indeed, who never fly, are frequently destitute of the latter kind; a circumstance which appears to confirm the suspicion that has often been entertained, that the simple eyes are chiefly instrumental in the vision of distant objects. Latreille describes two species of ants, in which he could not discover the least appearance whatsoever of eyes, although he employed a high magnifying power in examining them. One of these (the *Formica cæca*) is a foreign species, inhabiting the forests of Guiana, and of which the history is therefore little known. The other (the *Formica contracta*) is met with in the vicinity of Paris. It always conceals itself during the day under stones, or in obscure recesses, where no light can penetrate; and emerges from its retreat only during the night. It is much less social in its habits than other ants, collecting in groups only of about a dozen individuals, and appears to be far inferior in sagacity to the rest of the tribe.

Ants possess a considerable acuteness of smell, a sense which appears to be useful not only in directing them to their food, but also, as Bonnet first remarked, in enabling them to follow by the scent the track of their companions. If the end of the finger be passed two or three times across the line of their march, so as to brush off the odorous particles with which the ants who had already passed that way may have impregnated the track, those who follow immediately stop on arriving at the place where the experiment has been made, and afterwards direct their course irregularly, till they have passed over the space touched by the finger, when they soon find the path, and proceed with the same confidence as before. Bonnet repeated this experiment frequently, and always with the same result. Latreille has endeavoured to discover the seat of smell, which had long been suspected to reside in the antennæ. He, with this view, deprived several labouring ants of these organs, and replaced them near their nests. When thus mutilated, they wandered to and fro in all directions, as if they were delirious, and utterly unconscious of where they were going. Some of their companions were seen to notice their distress, and, approaching them with apparent compassion, applied their tongues to the bleeding wounds of the sufferers, and anointed them with a liquor which they caused to flow from their own mouths. This trait of sensibility was repeatedly witnessed by Latreille, while he was observing their actions with a magnifying lens.

It is indeed evident that, in all insects, the antennæ are organs of the greatest utility in conveying impressions from external objects. But in the ant, independently of their importance as organs of touch, they appear to be of still greater consequence to the welfare of the individual, and of the community to which it belongs, by being the

chief instruments which enable them to communicate to one another intelligence in which they are mutually interested, and on which they are called upon immediately to act. Mr Huber, to whom we are indebted for a variety of curious observations on this subject, has given the name of *Language Antennal* to this species of intercourse. The situation of the antennæ, which are placed in front of the head, their great mobility, their peculiar mechanism, which presents a series of phalanges having great freedom of play, and endowed with exquisite sensibility, conspire to fit them admirably for the function which he assigns to them,—that of producing a variety of different impressions, when applied in different ways to the antennæ or other parts of those ants with which they come in contact. Thus the signal of danger, which consists in the ant which gives the alarm striking its head against the corslet of the other, is propagated from ant to ant with astonishing quickness, throughout the whole society. For a few minutes a general ferment prevails, as if they were deliberating what measures to pursue; but their resolution is soon formed, and they are ready to rush in a body against the enemy. Any small animal that is discovered to have insolently invaded their repose is certain of falling a victim to their resentment, unless he can make a precipitate retreat, which he seldom effects without being covered with the bites of these furious insects. They are not, however, equally jealous of the intrusion of every kind of insect, for woodlice are often found in the interior of the nest, to whom, according to Latreille, they offer no molestation. Ants appear to be incapable of emitting sounds, so as to communicate with one another at a distance; and there is, indeed, no evidence that they possess the sense of hearing. The consideration of the sense of taste naturally comprehends that of their food, to which we shall therefore next proceed.

Very erroneous opinions were prevalent with regard to the food of ants, which have often been supposed to consume corn, and to do great injury to plants by devouring their roots or stems. The truth is, that they are chiefly carnivorous insects, preying indiscriminately on all the softer parts of animals, and especially the viscera of other insects. These, indeed, they will often attack when alive, and overpower by dint of numbers; either devouring their victim on the spot, or dragging it a prisoner into the interior of the nest. If, however, the game should be too bulky to be easily transported, they make a plentiful meal, and exert, like the bee, a power of disgorging a portion, and of imparting it to their companions at home: and it appears that they are even able to retain at pleasure the nutricious juices unchanged for a considerable time. The rapidity with which they consume, and in fact anatomize, the carcass of any small bird or quadruped that happens to fall in their way, is well known, and furnishes an easy method of obtaining natural skeletons of these animals, by placing their dead bodies in the vicinity of a populous ant-hill. In hot climates, where they multiply to an amazing extent, their voracity and boldness increase with their numbers. Bosman, in his description of Guinea, states that, in one night, they will devour a sheep, leaving it a fine skeleton; while a fowl is for them only the amusement of an hour. In these situations they will venture to attack even living animals of considerable size. Rats and mice often become their victims. The sugar-ants of Grenada cleared every plantation which they visited of rats and other vermin, which they probably effected by attacking their young. Poultry, or other small stock, could not be raised without the greatest difficulty; and the eyes, nose, and other emunctories of the bodies of dying or dead animals, were instantly covered with them. They generally, indeed, begin their attacks on the most sensible parts, which have the finest cuticle; and, accumulating in great numbers about the nostrils, destroy the animal by interrupting respiration. Negroes with sores had difficulty in keeping the ants from assailing them. Their power of destruction keeping pace with their increase of numbers, it is hardly possible to assign limits to either; and the united hosts of this diminutive insect have often become formidable to man himself. A story is related by Prévost, in his *Histoire Générale des Voyages*, of an Italian missionary, resident in Congo, who was awaked by his negroes in great alarm at the house being invaded by an immense army of ants, which poured in like a torrent, and before he could rise had already mounted upon his legs. They covered the floor and passages, forming a stratum of considerable depth. Nothing but fire was capable of arresting their progress. He states that cows have been known to be devoured in their stalls by these daring devastators. Smith, in his *Voyages to Guinea*, reports that at Cape Corse the castle was attacked by legions of ants, who were preceded by thirty or forty, apparently acting as guides. It was at day-break when they made this incursion, entering first by a chapel, on the floor of which some negro servants were lying. Assailed by this new enemy, they fled with precipitation, and gave the alarm to their master, who, on awaking, could hardly recover from his astonishment at beholding the advancing multitude, which extended for a quarter of a mile before him. There was not much time for deliberation; and a happy expedient was adopted of putting a long train of gunpowder across the line of their march, and extending it to their flanks, which had already begun to deploy, and, setting fire to the whole, millions were destroyed at one blow; which so intimidated the rest, that the whole army retreated in disorder, and did not renew the attack.

Descriptions of ant-hills of immense size abound in books of travellers who have visited tropical regions. Mr Campbell (*Account of Travels in South Africa*, published in 1815) observed in the district of Albany, at the Cape, an ant-hill, five feet high, and twelve in circumference. In the forests of Guiana, according to M. Malouet, they attain the height of from fifteen to twenty feet; and, when viewed from a distance on these widely extended savannas, resemble the rude huts of savages; but they contain a race more ferocious than the savage or the tiger himself, and cannot be approached by men without the utmost danger of being devoured. When new settlers, who are clearing the country, meet with any of these in their progress, they must immediately desist from their task, and even abandon the neighbourhood, unless they can speedily destroy the enemy in the very heart of the citadel which protects him, and from which he is able to pour an overwhelming number of combatants. The only method of accomplishing this is to dig a trench all round the ant-hills, and, after having filled it with dry wood and set fire to it on every side, by lighting it quickly in different places, so as to cut off all retreat to the ants, to batter down the edifice with cannon. The ants, thus scattered, soon perish in the flames.

The chief, if not the only vegetable substance which is at all alluring to their appetite, is *sugar*. They not only eat it in substance, but are fond of all fluids that contain it in any quantity,—such as the secretions which exude from many trees, and compose what has been termed the honey-dew; and the saccharine juice which is excreted from the bodies of many of the insects belonging to the genus Aphis. This latter species of food they appear to relish above all others: it resembles honey in its qualities, and is sucked with avidity from the insect which yields it, and which appears in no respect to suffer from the operation. Boissier de Sauvages was the first who noticed this

singular fact; and Mr P. Huber has ascertained a number of curious circumstances attending it. He conceives that the liquor is given out voluntarily by the aphis, at the solicitation of the ant, who for this purpose strikes it gently and repeatedly with its antennæ, using the same motions as it does when caressing its young; and remarks, that the aphis retains this liquor for a longer time, where the ants are not at hand to receive it. A single aphis may often be seen surrounded by three or four ants who are feeding on the honey, and deriving from it a plentiful meal. It does not appear that the aphis uses any exertion to avoid the ants, who are thus dependent on its bounty; for those provided with wings are quite as passive under these circumstances as the rest. They are, however, of an extremely sluggish nature, and may be seen for days on the same stem, in a state of indolent repose, and averse to use their wings.

A singular observation has been recently made by Professor Savi (the younger) of Pisa, in relation to a species of Italian ant, the nest of which is inhabited by a small grasshopper. These animals do not appear to dwell in the same excavations in a merely casual manner, but they are united by some unaccountable bond of union, which renders the society of the one indispensable to the comfort of the other. The association of the ant and the aphis before alluded to is of a dissimilar nature, being the result of force on the one hand, and of necessity on the other. But, as far as it is possible to judge from the observations hitherto recorded, the cohabitation of the ant and the grasshopper is of a more refined and disinterested kind. It is really impossible at present to account for it on any other principle than that of an affectionate interest in each other's society; for no direct advantage appears to result to either party. On this account Signor Savi has named the grasshopper *gryllus myrmecophilus*.[1] He proved the friendly alliance which subsists between these species, by watching the migratory and other movements of the ants themselves, during which he discovered that they always carried their little grasshoppers along with them. These latter, during fine weather, are seen to sport and play in the vicinity of the ant-nests, into which they immediately betake themselves during any unfavourable change of the air, or the approach of threatened danger.

The cultivation of the sugar-cane in the West Indian islands has often been severely checked by the ravages of ants; but the injury they occasion arises altogether from their undermining the roots, in order to establish their nests where they can be protected from heavy rains, and secured against agitation from violent winds; advantages which the sugar-cane affords them in a very great degree. No part of the plant constitutes their food; and the same is true of those trees among the roots of which they burrow, and of which they speedily occasion the destruction, by preventing the access of moisture.

Ripe fruits are often attacked by ants, probably on account of the sugar they contain; and, for the same reason, the buds of trees are infested with these insects, and often injured by their depredations. There is no evidence that they at any time feed upon corn or other vegetable seed. This point has been well established by Mr Gould; and Bonnet, who kept a colony of ants prisoners in his study, observed, that, however long they had been kept without food, still they never touched the corn that he put before them. Honey and sweetmeats have strong attractions for ants, who, if they once discover their way to a magazine of these dainties, will immediately communicate the tidings to the rest of the society, and, leading them to the spot, a regular path will soon be established, which will continue to be crowded with a train of depredators so long as any thing remains to be pilfered. It is, however, certain, notwithstanding the assertion of Bomare, who compares them to the miser, whose chief pleasure consists in contemplating the riches he has amassed in his coffers, that ants are not in the habit of hoarding provisions for future consumption. They grow torpid when the cold exceeds 27° of Fahrenheit, and in that state require no food; and the aphis affords them sufficient nourishment at other periods of the winter.

Their nests.

In building their nests, each species of ant follows its own peculiar mode of construction, and employs different materials for this purpose. Many form them of clay, and particularly the smaller species; one set building up a regular series of apartments in successive stories, often forty in number, with materials which are furnished to them by another set of workers, who are excavating the ground below. The cielings are supported throughout by small pillars in some parts, and by vertical walls in others; while broad arches are in other places raised, in order to protect larger spaces, and to admit of lengthened passages of communication throughout a long extent of apartments. These ants can proceed in the building only at such times as the earth has been softened by rain or dew, and the atmosphere is at the same time sufficiently moist to allow of the materials cohering firmly before they dry. Such are probably the ants which Pliny mentions as working by moonlight. On one occasion, when the ants, under the inspection of Mr Huber, had discontinued their labours on account of too great dryness in the atmosphere, he succeeded in getting them to renew their operations by sprinkling water upon them with a wet brush, in imitation of a natural shower. They carefully close the doors of their habitations every night, in order to prevent the intrusion of other insects; and a few remain on the outside during the night as sentinels, to give alarm in case of danger. Some species of ants collect fragments of leaves, of bark, or of straw, with which they construct more permanent and artificially constructed nests than the former. Others employ nothing but the fine powder which they collect from decayed wood. Some, for greater security, establish themselves under a large stone, or in the crevices of decayed buildings. Several tribes, on the other hand, penetrate into the solid substance of wood, which they scoop out into numerous cells, leaving only intermediate partitions of extreme tenuity, just of the strength sufficient to enable the whole fabric to support itself; while it crumbles into powder when pressed between the fingers.

Fecundation, growth of their young.

We shall now take a brief review of the principal circumstances relating to the fecundation of the ant, and the evolution and growth of the young. The former is effected very generally during the flight of the females, in which they are accompanied by the males; both appearing to be provided with wings chiefly for this object. A certain number of the females that are impregnated, are also, by the assistance of their wings, enabled to reach distant situations, where they become respectively the founders of new colonies. The males, on the other hand, having fulfilled the office for which nature had destined them, are left to perish on the spot where they descend, being removed from those who formerly administered to them food, and being destitute of the means of procuring subsistence for themselves. Immense swarms of ants are occasionally met with; and some have been recorded of such prodigious density and magnitude as to darken the

[1] *Biblioteca Italiana*, tomo xv. p. 217.

air like a thick cloud, and to cover the ground to a considerable extent where they settled. Mr Gleditsch describes, in the *History of the Berlin Academy* for 1749, shoals of a small black ant which appeared in Germany, and formed high columns in the air, rising to a vast height, and agitated with a curious intestine motion, somewhat resembling the aurora borealis. A similar flight of ants is spoken of by Mr Acolutte, a clergyman of Breslaw, which resembled columns of smoke, and which fell on the churches and the tops of the houses, where the ants could be gathered by handfuls. In the German *Ephemerides*, Dr Charles Rayger gives an account of a large swarm, which passed over the town of Posen, and was directing its course towards the Danube. The whole town was strewed with ants, so that it was impossible to walk without trampling on thirty or forty at every step. And more recently, Mr Dorthes, in the *Journal de Physique* for 1790, relates the appearance of a similar phenomenon at Montpellier. The shoals moved about in different directions, having a singular intestine motion in each column, and also a general motion of rotation. About sunset they all fell to the ground; and, on examining the ants, they were found to belong to the *Formica nigra* of Linnæus.

The swarming of ants does not appear to be at all analogous to that of bees: its object seems to be confined to the propagation of the species, and is not the result of any co-operation of numbers, who associate together in search of a new habitation, in which an already populous assemblage may establish themselves. It would appear that the infant colonies consist of very small numbers, and are perhaps wholly the offspring of a common parent, who has migrated alone, or with but a few companions. The greater number of impregnated females alighting in the neighbourhood of the nest, are laid hold of by the labouring ants, who drag them to the nest, where they keep them prisoners till they are ready to deposit their eggs. It is very generally asserted that they also deprive them of their wings; but the later observations of M. Huber disprove that opinion. The impregnated females cast their wings of their own accord. They twist and contort these organs in various directions, till they finally drop off. Such as are unimpregnated have not been observed to perform this singular action. Each female is at this period attended by a numerous retinue of labourers, who treat her with the greatest deference, and are solicitous to anticipate all her wants. Contrary to what happens among bees, many females inhabit the same nest, and live together in the utmost harmony. The eggs, when first deposited, are very small, but become considerably larger before the larva is excluded, being apparently nourished by absorption; for the ants to whose care they are confided are perpetually licking them with their tongues,—a fact which, however curious, is by no means a solitary one in the history of insects. The larva comes forth at the end of a fortnight, and appears in the form of a transparent maggot, with a head and wings, but without any external organs of motion. They are in this state fed by their nurses with a fluid disgorged from their stomachs; and, in the course of their transformation to the state of nympha, and of perfect insect, are still dependent upon their assistance. These affectionate guardians help them to extricate themselves from the web of the cocoon, to unfold the duplicatures of their wings, and supply them with food, till they are capable of procuring it for themselves. The young ant is an exceedingly tender and delicate animal, easily destroyed by any considerable variation of temperature, or by excessive humidity; and great care and attention appear to be required to bring it to maturity: it appears to be the constant business of the ants which remain at home to convey them to different parts of the nest, where the temperature is suited to them; and whenever danger threatens they show the utmost solicitude to remove them to situations of security.

Their sagacity.

Very different degrees of sagacity belong to different tribes of ants. Many traits in the history of the larger kinds, as related by Huber, are of so singular a character as to be scarcely credible if we had received them from a less reputable authority, and if we were not already prepared to admit them, from our knowledge of many equally curious circumstances in the economy of bees, which have been established by the concurrent testimony of the most scrupulous observers. Some tribes of ants, according to this naturalist, who are peculiarly fond of the honey which exudes from the aphis, convey many of these insects into their own nests, lodging them near the vegetables on which they feed, but keeping them prisoners within their habitations, and assigning to them distinct apartments in the subterranean recesses of their dwellings. As if conscious of the future advantages they may derive from these insects, they collect their eggs, and superintend their hatching with the same care which they bestow on the eggs of their own species. The aphis lives in perfect harmony with its keepers, who, so far from molesting it, defend it with courage against ants belonging to other nests, who frequently attempt to get possession of them. Occasionally they are lodged by the ants in fortified buildings, which they construct at a distance from the nest, in situations where they are most secure from invasion. The aphis is not the only genus of insect which furnishes this kind of provision to the ant; the kermes and gall-insect are employed occasionally for the same purpose, and are found domesticated in the nests of ants, at the same time that they contain several species of aphis, and from all of which they collect nutriment.

Their wars.

This picture of domestic harmony is strongly contrasted with the scenes of ferocious contention which are occasionally exhibited between the inhabitants of neighbouring nests; nature appearing to have instilled, together with the love of social order, the same passions of rivalry, of ambition, and of revenge, of which we deplore the operation among beings of a higher order. War, the scourge of the human species, exerts its desolating power among the tribes of gregarious insects, and tends to check their otherwise excessive increase of number. The battles which take place between rival colonies of ants are often on a scale of prodigious magnitude: millions of combatants engage on either side with a fury and pertinacity that is truly astonishing. Their weapons of offence are the jaws, which are capable of inflicting a deep bite, and of instilling into the wound a highly acrid liquor; and also, in many species, a sting resembling in situation and structure that of the bee, and likewise containing a venomous juice. The liquor is well known to possess acid properties, and, though long supposed by chemists to contain a peculiar acid, which was denominated the Formic, has been satisfactorily shown by Fourcroy and Vauquelin to consist of the acetic and malic acids, combined with a portion of acid animal matter, to which it owes its peculiar taste and smell. It is extremely volatile and pungent, and is capable of being thrown out by the ant, when irritated, in considerable quantities. Roux, in the *Journal de Médicine* for 1762, reports a number of experiments which were made by exposing animals to its influence. Frogs were killed by the vapour from an ant's nest in less than five minutes; and persons breathing it, when of a certain intensity, were nearly suffocated, or were seized with fever, followed by an extensive cutaneous eruption, which terminated in desquamation of the cuticle.

Some of the most daring and courageous species, such as that which M. Huber calls the *Amazon-ant*, make it the business of their lives to attack the nests of the weaker species, and succeed, after a desperate conflict, in plundering them of their eggs and larvæ, which they convey to their own nests. These are hatched and reared by ants of the same species as themselves, who may be considered as auxiliaries to the amazons, and who had themselves, at some former period, been kidnapped from their parent nest by the amazons. Thus, a society is formed among different species of insects, to which no parallel exists but in the human race. The amazons live without labour; they are attended, fed, and cherished by the ants which they have procured by this kind of slave-trade, and who take as much care of their offspring as they do of those of their own species. Perfect order is preserved, and the natural instinct of hostility, which in another condition of the society exists between the two tribes, seems in the auxiliaries completely extinguished, by their being educated with the race of their original oppressors.

Ants have numerous enemies among quadrupeds and birds; and some, as the ant-eater, dasypus, and manis or pangolin, together with the tribe of woodpeckers, devour a very large proportion. The *Formica leonis*, or myrmelion, feeds almost wholly on these insects. The bees at the Cape, according to Mr Campbell, frequently drive out the ants from their nests, of which they take possession themselves. Ants are also infested by lice, which, as may well be imagined, are so minute as to be invisible without the assistance of a very high magnifying power. They are stated by Redi, who discovered them, to resemble in shape those of the fowl and the dove.

Mode of destroying ants.

The most effectual mode of destroying ants is to pour boiling water into their nests, which destroys at once both the perfect insects and their eggs and larvæ; so that those who, being from home, had escaped the general catastrophe, finding it impossible to repair the loss, abandon the spot, and disperse. The addition of urine, or of soot, or still better of tobacco, which may be infused in the water, will render it much more efficacious. A decoction of walnut-leaves or lime-water will also generally answer. The night is the best time for applying these remedies, as the ants are then all collected in the nest. Arsenic is exceedingly destructive to ants, and affords another ready mode of getting rid of those that intrude into cupboards or pantries: it may, for this purpose, be mixed with sugar, or kneaded with any kind of provision, and placed in the paths they are observed to frequent. Corrosive sublimate is also highly poisonous to them, and myriads of the sugar-ants at Grenada were destroyed by means of it; and it is stated to have had the effect of rendering the ants so outrageous that they destroyed each other, as could be seen by a magnifying glass, and even, though less distinctly, by the naked eye. It appears also that this effect was produced even when they only came in contact with the poison. The whole island, however, was so overrun with these ants, that the numbers that could be destroyed by these means bore no sensible proportion to the whole; and recourse was had to fire as more applicable to destruction on a larger scale. It was observed that when wood, burnt to the state of charcoal, without flame, and immediately taken from the fire, was laid in their way, they crowded to it in such amazing numbers as soon to extinguish it, though thousands perished by so doing. Holes were therefore dug at proper distances in a cane-piece, and fire made in each of them. Prodigious quantities perished in this way; for those fires, when extinguished, appeared in the shape of mole-hills, from the numbers of dead that were heaped upon them. But as none of the females or young brood were destroyed by this expedient, the ants soon re-appeared in as great numbers as before; and the island would probably have continued subject to this scourge, had it not been for the occurrence of the great hurricane of 1780, which at once cleared all the islands of this dreadful pest, by which the sugar-cane plantations had been threatened with total ruin. (Y.)

For the specific descriptions and systematic arrangement of the different kinds of ants, see ENTOMOLOGY.

ANT-Eater. See MAMMALIA, *Index.*

ANT-Hills are little hillocks of earth which the ants throw up for their habitation and the breeding of their young. They are a very great mischief to dry pastures, not only by wasting so much land as they cover, but by hindering the scythe in mowing the grass, and yielding a poor hungry food, pernicious to cattle. The manner of destroying them is to cut them into four parts from the top, and then dig into them so deep as to take out the core below, so that when the turf is laid down again it may lie somewhat lower than the level of the rest of the land. By this means it will be wetter than the rest of the land, and this will prevent the ants from returning to the same place, which otherwise they would certainly do. The earth that is taken out must be scattered to as great a distance every way as may be, otherwise they will collect it together, and make another hill just by. The proper time for doing this is winter; and if the places be left open, the frost and rains of that time of the year will destroy the rest; but in this case care must be taken that they are covered up early enough in the spring, otherwise they will be less fertile in grass than the other places. In Hertfordshire they use a particular kind of spade for this purpose. It is very sharp, and formed at the top into the shape of a crescent, so that the whole edge makes up more than three fourths of a circle; this cuts in every part, and does the business very quickly and effectually. Others use the same instruments that they do for mole-hills. Human dung is a better remedy than all these, as is proved by experiment; for it will kill great numbers of them, and drive all the rest away, if only a small quantity of it be put into their hills.

ANTA, in the *Ancient Architecture*, a square pilaster placed at the corners of buildings.

ANTA, or *Ahanta*, a small kingdom on the Gold Coast of Africa, extending about ten leagues in length, between Apollonia and the Fantee territory. The country is covered with large trees, among which stand a number of fine villages. The soil is exceedingly rich, and considered superior to any other on the Gold Coast. Every kind of tropical produce is there reared with advantage, and the sugar-cane grows to a great size and of excellent quality. It contains various species of valuable dyeing and ornamental woods, one of which is considered little inferior to mahogany. There are supposed to be mines of gold in the territory; but the ruling powers do not encourage the working of them, which would perhaps require more skill than the people possess. Gold, however, may be obtained in considerable quantities, being brought down from the interior countries of Warsaw and Dinkira. The air is also much more salubrious than in any other place of this coast, the number of deaths being observed to be smaller than in any other part of Guinea. Formerly Anta was potent and populous, inhabited by a bold and rapacious people, who greatly annoyed the Europeans by their frequent incursions; but by continual wars with their neighbours they are now greatly enfeebled, and are disposed to seek protection from the Dutch and other Europeans who have forts on this coast, and to maintain a friendly intercourse with them. Axim, Dixcove, and Succondee are the principal towns; and many commodious

creeks and havens are found along the coast. The British government, however, having since the abolition of the slave-trade limited in a remarkable degree its intercourse with the Gold Coast, has withdrawn the garrisons which it maintained in the three places above mentioned.

ANTACIDS, an appellation given to all medicines proper to correct acid or sour humours. Under the class of Antacids come, 1. Absorbents, as chalk, coral, sea-shells, hæmatites, and steel filings; 2. Obtundents, as oils and fats; 3. Immutants, as lixivious salts and soaps.

ANTÆUS, in fabulous history, a giant of Libya, son of Neptune and Terra. Designing to build a temple to his father, of men's sculls, he slew all he met. In his combat with Hercules he is said to have received strength from the earth every time he was thrown upon it, which Hercules perceiving, lifted him up from the ground and squeezed him to death.

Antæus was king of Mauritania; and from several circumstances, with which we are supplied by various authors, it appears extremely probable that he was the same person with Atlas. They were both of them the sons of Neptune, who reigned over Mauritania, Numidia, and a great part of Libya; as may be naturally inferred from his having such particular marks of distinction conferred upon him by the inhabitants of those regions: they both ruled with absolute power over a great part of Africa, particularly Tingitana: Hercules defeated and slew Antæus in the same war wherein he took the Libyan world from Atlas: both Atlas and Antæus invaded Egypt, and contended with Hercules in the wars with the gods, and were both vanquished by him: Antæus, as well as Atlas, was famed for knowledge in the celestial sciences: from all which we may fairly conclude that they were the same king of Mauritania.

The golden apples so frequently mentioned by the old mythologists were the treasures that fell into Hercules's hands upon Antæus's defeat, the Greeks giving the oriental word מלא, *riches*, the signification annexed to their own term, μηλα, *apples*. After the most diligent and impartial examination of all the different hypotheses of historians and chronologers relating to Atlas and Antæus, we find none so little clogged with difficulties as that of Sir Isaac Newton. According to that illustrious author, Ammon, the father of Sesac, was the first king of Libya, or that vast tract extending from the borders of Egypt to the Atlantic Ocean, the conquest of which country was effected by Sesac in his father's lifetime. Neptune afterwards excited the Libyans to rebellion against Sesac, slew him, and then invaded Egypt under the command of Atlas or Antæus, the son of Neptune, Sesac's brother and admiral. Not long after, Hercules, the general of Thebais and Ethiopia, for the gods or great men of Egypt, reduced a second time the whole continent of Libya, having overthrown and slain Antæus near a town in Thebais, from that event called Antæa or Antæopolis. This is the notion advanced by Sir Isaac Newton, who endeavours to prove that the first reduction of Libya by Sesac happened a little above a thousand years before the birth of Christ, as the last by Hercules did some few years after.

ANTAGOGUE, in *Rhetoric*, a figure by which, when the accusation of the adversary is unanswerable, we load him with the same or other crimes.

ANTALO, a considerable town of Abyssinia, capital of the flat and fertile district of Enderta, which is dependent on Tigré. The town is built along the declivity of a mountain, commanding fine views over an extensive range of territory to the south. Though considered in Abyssinia a place of importance, its absolute magnitude is by no means very large. There are not more than 1000 houses, which, with the exception of that destined for the residence of the Ras or sovereign of Tigré, are no better than clusters of huts with conical thatched roofs. As Antalo stands near the border of the provinces now occupied by the Galla, that fierce and turbulent race, who have occupied a great part of Abyssinia, and whose armies continually threaten the rest, the Ras, to watch their movements, has fixed his usual residence at Antalo. There is at this place a manufactory of spears, which are much esteemed, and exported to various parts of the country.

ANTANACLASIS, in *Rhetoric*, a figure which repeats the same word, but in a different sense; as, *dum vivimus, vivamus.*

ANTARCTIC, in a general sense, denotes something opposite to the northern or arctic pole. Hence antarctic circle is one of the lesser circles of the sphere, and distant only 23° 30′ from the south pole, which is likewise called antarctic for the same reason.

ANTARES, in *Astronomy*, the name of a star of the first magnitude, called also the scorpion's heart. Its R. A. on 1st January 1830 was 16 h. 18 m. 59·77 sec.; An. Pr. +3·66 sec.; S. D. 26° 2′ 23″·5; An. Pr. +8″·6.

ANTAVARE, a province of the island of Madagascar, lying about 21° 30′ S. lat. and bounded by the province and cape of Manousi. The greater part of it is watered by the river Mananzari, whose source is in the red mountains of Ambohitsmene.

ANTEAMBULONES, in *Roman Antiquity*, servants who went before persons of distinction to clear the way before them. They used this formula, *Date locum domino meo*, i. e. Make room or way for my master.

ANTECEDENT, in general, something that goes before another, either in order of time or place.

Antecedent, in *Grammar*, the words to which a relative refers.

Antecedent, in *Logic*, is the first of the two propositions in an enthymeme.

Antecedent, in *Mathematics*, is the first of two terms of a ratio, or that which is compared with the other.

ANTECESSOR, one that goes before. It was an appellation given to those who excelled in any science. Justinian applied it particularly to professors of the civil law; and, in the universities of France, the teachers of law take the title *antecessors* in all their theses.

ANTECURSORES, in the Roman armies, a party of horse detached before, partly to get intelligence, provisions, &c. and partly to choose a proper place to encamp in. These were otherwise called *antecessores*, and by the Greeks προδρομοι.

ANTEDILUVIANS, a general name for all mankind who lived before the flood, and so includes the whole of the human race from Adam to Noah and his family.

As Moses has not set down the particular time of any transaction before the flood, except only the years of the fathers' ages in which the several descendants of Adam in the line of Seth were begotten, and the length of their several lives, it has been the business of chronologers to endeavour to fix the years of the lives and deaths of those patriarchs, and the distance of time from the creation to the deluge. In this there could be little difficulty, were there no varieties in the several copies we now have of Moses's writings; which are, the Hebrew, the Samaritan, and the Greek version of the Septuagint; but as these differ very considerably from one another, learned men have been much divided in opinion concerning the chronology of the first ages of the world.

That the reader may the better judge of the variations in the three copies in this period, they are exhibited in the following table, with the addition of those of Josephus as corrected by Dr Wells and Mr Whiston.

Antediluvians.

A Table of the Years of the Antediluvian Patriarchs.

	Their Ages at their Sons' Birth.				Years they lived after their Sons' Birth.			Length of their Lives.		
	Heb.	Sam.	Sept.	Jos.	Heb.	Sam.	Sept.	Heb.	Sam.	Sept.
Adam	130	130	230	130	800	800	700	930	930	930
Seth	105	105	205	105	807	807	707	912	912	912
Enos	90	90	190	90	815	815	715	905	905	905
Cainan	70	70	170	70	840	840	740	910	910	910
Mahalaleel	65	65	165	65	830	830	730	895	895	895
Jared	162	62	162	62	800	785	800	962	847	962
Enoch	65	65	165	65	300	300	200	365	365	365
Methuselah	187	67	167	187	782	653	802	969	720	969
Lamech	182	53	188	182	595	600	565	777	653	753
Noah was aged at the Flood	600	600	600	600						
To the Flood	1656	1307	2242	1556						

As to the customs, policy, and other general circumstances of the antediluvians, we can only form conjectures.

The only thing we know as to their religious rites is, that they offered sacrifices, and that very early, both of the fruits of the earth and of animals; but whether the blood and flesh of the animals, or only their milk and wool, were offered, is a disputed point.

The antediluvians seem to have spent their time rather in luxury and wantonness, to which the abundant fertility of the first earth invited them, than in discoveries or improvements, which probably they stood much less in need of than their successors. Some authors have supposed astronomy to have been cultivated by the antediluvians, though this is probably owing to a mistake of Josephus; but it is to be presumed that the progress they made therein, or in any other science, was not extraordinary; it being even very doubtful whether letters were so much as known before the flood.

As to their politics and civil constitutions, we have not so much as any circumstances whereon to build conjecture. It is probable that the patriarchal form of government, which certainly was the first, was set aside when tyranny and oppression began to take place, and much sooner among the race of Cain than among that of Seth. It seems also that their communities were but few, and consisted of vastly larger numbers of people than any formed since the flood; or rather it is a question, whether, after the union of the two great families of Seth and Cain, there were any distinction of civil societies, or diversity of regular governments at all. It is more likely that all mankind then made but one great nation, though living in a kind of anarchy, divided into several disorderly associations; which, as it was almost the natural consequence of their having in all probability but one common language, so it was a circumstance which greatly contributed to that general corruption which otherwise perhaps could not have so universally overspread the antediluvian world. And for this reason chiefly, as it seems, so soon as the posterity of Noah were sufficiently increased, a plurality of tongues was miraculously introduced, in order to divide them into distinct societies, and thereby prevent any such total depravation for the future.

One of the most extraordinary circumstances which occurs in the antediluvian history, is the vast length of human lives in those first ages, in comparison with our own. Few persons now arrive at eighty or a hundred years, whereas before the flood they frequently lived to near a thousand. Some, to reconcile this with probability, have imagined that the ages of those first men might possibly be computed, not by solar years, but months; an expedient which reduces the length of their lives rather to a shorter period than our own. But for this there is not the least foundation; besides, many absurdities would thence follow,—such as their begetting children at about six years of age, as some of them in that case must have done, and the contracting of the whole interval between the creation and the deluge to considerably less than two hundred years, even according to the larger computation of the Septuagint.

Josephus, the Jewish historian, and some Christian divines, are of opinion, that before the flood, and some time after, mankind in general did not live to such a remarkable age, but only a few beloved of God, such as the patriarchs mentioned by Moses. They reason in this manner: Though the historian records the names of some men whose longevity was singular, yet that is no proof that the rest of mankind attained to the same period of life, more than that every man was then of a gigantic stature because he says *in those days there were giants upon the earth.* Besides, had the whole of the antediluvians lived so very long, and increased in numbers in proportion to their age, before the flood of Noah, the earth could not have contained its inhabitants, even supposing no part of it had been sea. And had animals lived as long, and multiplied in the same manner, as they have done since, they would have consumed the whole produce of the globe, and the stronger would have extinguished many species of the weaker. Hence they conclude, that for wise and good ends, God extended only the lives of the patriarchs, and a few besides, to such an extraordinary length. But most writers maintain the longevity of mankind in general in the early world, not only upon the authority of sacred, but likewise of profane history.

The antediluvian world was in all probability stocked with a much greater number of inhabitants than the present earth either actually does, or perhaps is capable of containing or supplying. This seems naturally to follow, from the great length of their lives, which exceeding the present standard of life in the proportion at least of ten to one, the antediluvians must accordingly in any long space of time have doubled themselves, at least in about the tenth part of the time in which mankind do now double themselves. Upon these points the reader may consult Cockburn's *Treatise upon the Deluge,* Shuckford's *Connections,* Faber's *Horæ Mosaicæ,* and the *Ancient Universal History.*

ANTEGO. See Antigua.

ANTEJURAMENTUM, by our ancestors called *juramentum calumniæ,* an oath which anciently both accuser and accused were to take before any trial or purgation. The accuser was to swear that he would prosecute the

criminal; and the accused to make oath, on the day he was to undergo the ordeal, that he was innocent of the crime charged against him,

ANTELOPE. See MAMMALIA, *Index.*

ANTELUCAN, in ecclesiastical writers, is applied to things done in the night, or before day. We find frequent mention of the antelucan assemblies (*Cœtus antelucani*) of the ancient Christians in times of persecution for religious worship.

ANTEMURALE, in the ancient military art, denotes much the same with what the moderns call an *outwork.*

ANTENATI, in modern English history, is chiefly understood of the subjects of Scotland born before King James the First's accession to the English crown, and alive after it. In relation to these, those who were born after the accession were denominated *Postnati.* The antenati were considered as aliens in England, whereas the postnati claimed the privilege of natural subjects.

ANTENCLEMA, in *Oratory,* is where the whole defence of the person accused turns on criminating the accuser. Such is the defence of Orestes, or the oration for Milo: *Occisus est, sed latro. Exsectus, sed raptor.*

ANTENICENE, in ecclesiastical writers, denotes a thing or person prior to the first council of Nice. We say the Antenicene faith, Antenicene creeds, Antenicene fathers.

ANTENNÆ. See ENTOMOLOGY, *Index.*

ANTENOR, a Trojan prince, came into Italy, expelled the Enganians on the river Po, and built the city of Padua, where his tomb is said to be still extant.

ANTEPAGMENTA, in the *Ancient Architecture,* the jambs of a door. They are also ornaments or garnishings, in carved work, of men, animals, &c. made either of wood or stone, and set on the architrave.

ANTEPENULTIMA, in *Grammar,* the third syllable of a word from the end, or the last syllable but two.

ANTEPILANI, in the Roman armies, a name given to the *hastati* and *principes,* because they marched next before the *triarii,* who were called *pilani.*

ANTEPILEPTICS, among physicians, medicines esteemed good in the epilepsy.

ANTEPOSITION, a grammatical figure, whereby a word, which by the ordinary rules of syntax ought to follow another, comes before it; as when, in the Latin, the adjective is put before the substantive, the verb before the nominative case, &c.

ANTEPREDICAMENTS, among logicians, certain preliminary questions which illustrate the doctrine of predicaments and categories.

ANTEQUERA, a commandery in the province of Granada in Spain, extending over 165 square miles, between the cities of Granada, Seville, and Cordova, in a fertile soil, comprehending the city of the same name, and eight towns, besides several villages, having in the whole a population of about 40,000.

ANTEQUERA, a city of Spain, in the province of Seville, in Andalusia. It is situate in a beautiful and fertile valley, covered with olive-trees, around which, in all directions, lofty mountains rise to a great height, which contain valuable quarries of marble of every description. Near it is a saline lake, which supplies the inhabitants of the district with salt for all their culinary purposes. As long as the Moors possessed the kingdom of Granada, this city, from being the point which commands the eastern entrance to the plain, was a military post of vast importance, and its possession was perpetually contested by the rival monarchs on both sides of it. An ancient castle still remains, in which are preserved specimens of the various military weapons and accoutrements both of the Moors and the Christians of the 14th century. It contains about 14,000 inhabitants, employed in cultivation and in the manufactures of cloth and leather.

ANTEROS, in *Mythology,* one of the two Cupids who were the chief of the number. They are placed at the foot of the Venus de' Medici. This is represented with a heavy and sullen look, agreeably to the poetical description of him, as the cause of love's ceasing. The other was called Eros.

ANTESIGNANI, in the Roman armies, soldiers placed before the standards, in order to defend them, according to Lipsius; but Cæsar and Livy mention the *antesignani* as the first line or first body of heavy armed troops. The *velites,* who used to skirmish before the army, were likewise called *antesignani.*

ANTESTARI, in *Roman Antiquity,* signifies to bear witness against any one who refused to make his appearance in the Roman courts of judicature, on the day appointed, and according to the tenor of his bail. The plaintiff finding the defendant after such a breach of his engagement, was allowed to carry him into court by force, having first asked any of the persons present to bear witness. The person asked to bear witness in this case expressed his consent by turning his right ear, which was instantly taken hold of by the plaintiff; and this was to answer the end of a subpœna. The ear was touched upon this occasion, says Pliny, as being the seat of memory, and therefore the ceremony was a sort of caution to the party to remember his engagement.

ANTESTATURE, in *Fortification,* a small intrenchment made of palisadoes, or sacks of earth, with a view to dispute with an enemy the remainder of a piece of ground.

ANTHEM, a church song performed in cathedral service by choristers, who sung alternately. It was used to denote both psalms and hymns when performed in this manner; but at present anthem is used in a more confined sense, being applied to certain passages taken out of the Scriptures, and adapted to a particular solemnity. Anthems were first introduced, in the reformed service of the English church, in the beginning of the reign of Queen Elizabeth.

ANTHESPHORIA, in *Antiquity,* a Sicilian festival instituted in honour of Proserpine. The word is derived from the Greek ανθος, *flower,* and φερω, *I carry;* because that goddess was forced away by Pluto when she was gathering flowers in the fields. Yet Festus does not ascribe the feast to Proserpine, but says it was thus called because ears of corn were carried on this day to the temples. Anthesphoria seems to be the same thing with the *florifertum* of the Latins, and answers to the harvest-home among us.

ANTHESTERIA, in *Antiquity,* was a feast celebrated by the Athenians in honour of Bacchus. The most natural derivation of the word is from the Greek ανθος (*flos*), a flower, it being the custom at this feast to offer garlands of flowers to Bacchus.

The anthesteria lasted three days, the 11th, 12th, and 13th of the month, each of which had a name suited to the proper office of the day. The first day of the feast was called πιθοιγια, i. e. *opening of the vessels,* because on this day they tapped the vessels and tasted the wine. The second day they called χοος, *congius,* the name of a measure containing the weight of 10 pounds: on this they drank the wine prepared the day before. The third day they called χυτροι, *kettles:* on this day they boiled all sorts of pulse in kettles; which however they were not allowed to taste, as being offered to Mercury.

ANTHESTERION, in ancient chronology, the sixth month of the Athenian year. It contained 29 days, and answered to the latter part of our November and begin-

ning of December. The Macedonians called it *dæsion* or *desion*. It had its name from the festival anthesteria kept in it.

ANTHOLOGION, the title of the service-book used in the Greek church. It is divided into 12 months, containing the offices sung throughout the year, on the festivals of our Saviour, the Virgin, and other remarkable saints.

ANTHOLOGY, a discourse of flowers, or a selection of beautiful passages from various authors. It is also the name given to a collection of epigrams taken from several Greek poets.

ANTHONY, SAINT, was born in Egypt in 251, and inherited a large fortune, which he distributed among his neighbours and the poor, retired into solitude, founded a religious order, built many monasteries, and died anno 356. Many ridiculous stories are told of his conflicts with the devil, and of his miracles. There are seven epistles extant attributed to him.

St Anthony is sometimes represented with a fire by his side, signifying that he relieves persons from the inflammation called after his name; but always accompanied by a hog, on account of his having been a swine-herd, and curing all disorders in that animal. To do him the greater honour, the Romanists in several places keep at common charges a hog denominated *St Anthony's hog*, for which they have great veneration. Some will have St Anthony's picture on the walls of their houses, hoping by that to be preserved from the plague; and the Italians, who do not know the true signification of the fire painted at the side of their saint, concluding that he preserves houses from being burnt, invoke him on such occasions. Both painters and poets have made very free with this saint and his followers; the former by the many ludicrous pictures of his temptation, and the latter by divers epigrams on his disciples or friars.

ANTHONY, or *Knights of St ANTHONY*, a military order instituted by Albert duke of Bavaria, Holland, and Zealand, when he designed to make war against the Turks in 1382. The knights wore a collar of gold made in form of a hermit's girdle, from which hung a stick cut like a crutch, with a little bell, as they are represented in St Anthony's pictures.

St ANTHONY also gives the denomination to a religious order founded in France about the year 1095, to take care of those afflicted with St Anthony's fire (see the next article). It is said that in some places these monks assume to themselves a power of giving, as well as removing, the *ignis sacer*, or erysipelas; a power which stands them in great stead, for keeping the poor people in subjection, and extorting alms.

St ANTHONY's Fire, a name properly given to the erysipelas. Apparently it took this denomination, as those afflicted with it made their peculiar application to St Anthony of Padua for a cure. It is known that, anciently, particular diseases had their peculiar saints. Thus, in the ophthalmia, persons had recourse to St Lucia; in the toothache, to St Apollonia; in the hydrophobia, to St Hubert, &c.

ANTHORISMUS, in *Rhetoric*, denotes a contrary description or definition of a thing from that given by the adverse party. Thus, if the plaintiff urge, that to take any thing away from another without his knowledge or consent, is a theft; this is called ορος, or definition. If the defendant reply, that to take a thing away from another without his knowledge or consent, provided it be done with design to return it to him again, is not theft; this is an ανθορισμος.

ANTHRAX, a Greek term, literally signifying a burning coal, used by the ancients to denote a gem, as well as a disease more generally known by the name of *carbuncle*.

ANTHROPOGLOTTUS, among zoologists, an appellation given to such animals as have tongues resembling that of mankind, particularly to the parrot kind.

ANTHROPOLATRÆ, in *Ecclesiastical History*, an appellation given to the Nestorians, on account of their worshipping Christ, notwithstanding that they believed him to be a mere man.

ANTHROPOLATRIA, the paying of divine honours to a man: supposed to be the most ancient kind of idolatry.

ANTHROPOLITES, a term denoting petrifactions of the human body, as those of quadrupeds are called *zoolites*. See PETRIFACTION.

ANTHROPOLOGY, a discourse upon human nature. It is sometimes applied to designate the speculations and inquiries that have obtained concerning the varieties of the human race. See MAN.

ANTHROPOLOGY, among divines, denotes that manner of expression by which the inspired writers attribute human parts and passions to God.

ANTHROPOMANCY, a species of divination, performed by inspecting the entrails of a human creature.

ANTHROPOMORPHA, a term formerly given to the primates of that class of animals which have the greatest resemblance to the human kind.

ANTHROPOMORPHISM, among ecclesiastical writers, denotes the heresy or error of the Anthropomorphites. See the next article.

ANTHROPOMORPHITES, in *Ecclesiastical History*, a sect of ancient hereties, who, taking every thing spoken of God in Scripture in a literal sense, particularly that passage of Genesis in which it is said *God made man after his own image*, maintained that God had a human shape. They are likewise called *Audeans*, from Audeus their leader.

ANTHROPOMORPHOUS, something that bears the figure or resemblance of a man. Naturalists give instances of anthropomorphous plants, anthropomorphous minerals, &c. These generally come under the class of what are called *lusus naturæ*, or monsters.

ANTHROPOPATHY, a figure or expression by which some passion is ascribed to God, which properly belongs only to man.

ANTHROPOPHAGI (of ανθρωπος, *a man*, and φαγω, *to eat*, MEN-EATERS). That there have been, in almost all ages of the world, nations who have followed this barbarous practice, we have abundance of testimonies.

The Cyclops, the Lestrygons, and Scylla, are all represented in Homer as *Anthropophagi*, or man-eaters; and the female phantoms, Circe and the Sirens, first bewitched with a show of pleasure, and then destroyed. This, like the other parts of Homer's poetry, had a foundation in the manners of the times preceding his own. According to Herodotus, among the Essedonian Scythians, when a man's father died, the neighbours brought several beasts, which they killed, mixed up their flesh with that of the deceased, and made a feast. Among the Massagetæ, when any person grew old, they killed him and ate his flesh; but if he died of sickness they buried him, esteeming him unhappy. The same author also assures us that several nations in the Indies killed all their old people and their sick, to feed on their flesh. He adds, that persons in health were sometimes accused of being sick, to afford a pretence for devouring them. According to Sextus Empiricus, the first laws that were made were for the preventing of this barbarous practice, which the Greek writers represent as universal before the time of Orpheus.

Of the practice of anthropophagy in later times, we have the testimonies of all the Romish missionaries who have visited the interior parts of Africa, and even some parts of Asia. When America was discovered, this practice was found to be almost universal, insomuch that se-

veral authors have supposed it to be occasioned through a want of other food, or through the indolence of the people to seek for it; though others ascribe its origin to a spirit of revenge.

It appears pretty certain, from Dr Hawkesworth's account of the voyages to the South Seas, that the inhabitants of the island of New Zealand, a country unfurnished with the necessaries of life, eat the bodies of their enemies. It appears also to be very probable, that both the wars and anthropophagy of these savages take their rise from irresistible necessity, and owe their continuance to the dreadful alternative of destroying each other by violence, or of perishing by hunger.

Mr Marsden informs us that this horrible custom is practised by the Battas, a people in the island of Sumatra. "They do not eat human flesh," says he, "as a means of satisfying the cravings of nature, owing to a deficiency of other food; nor is it sought after as a gluttonous delicacy, as it would seem among the New Zealanders. The Battas eat it as a species of ceremony; as a mode of showing their detestation of crimes, by an ignominious punishment; and as a horrid indication of revenge and insult to their unfortunate enemies. The objects of this barbarous repast are the prisoners taken in war, and offenders convicted and condemned for capital crimes."

It may be said, that whether the dead body of an enemy be eaten or buried, is a matter perfectly indifferent. But whatever the practice of eating human flesh may be in itself, it certainly is relatively, and in its consequences, most pernicious. It manifestly tends to eradicate a principle which is the chief security of human life, and more frequently restrains the hand of the murderer than the sense of duty or the dread of punishment. Even if this horrid practice originates from hunger, still it must be perpetuated from revenge. Death must lose much of its horror among those who are accustomed to eat the dead; and where there is little horror at the sight of death, there must be less repugnance to murder.

ANTHROPOSCOPIA (from ανθρωπος, and σκοπεω, *I consider*), the art of judging or discovering a man's character, disposition, passions, and inclinations, from the lineaments of his body; in which sense anthroposcopia seems of somewhat greater extent than physiognomy or metoposcopy. Otto has published an Anthroposcopia, *sive judicium hominis de homine ex lineamentis externis.*

ANTHROPOTHYSIA, the inhuman practice of offering human sacrifices. See SACRIFICE.

ANTHYPOPHORA, in *Rhetoric*, a figure of speech, being the counterpart of an hypophora. See HYPOPHORA.

ANTI, a Greek preposition, which enters into the composition of several words, both Latin, French, and English, in different senses. Sometimes it signifies *before*, as an antichamber; and sometimes *opposite* or *contrary*, as in the names of these medicines, anti-scorbutic, anti-venereal.

ANTIBACCHIUS, in *Ancient Poetry*, a foot consisting of three syllables, the first two long, and the last one short: such is the word āmbīrĕ.

ANTIBES, a seaport town of France, in the department of Var, with a strong castle. Its territory produces excellent fruit; and the town stands opposite to Nice, in the Mediterranean. Long. 7. 9. E. Lat. 43. 42. N.

ANTICHRIST, among ecclesiastical writers, denotes a great adversary of Christianity, who is to appear upon the earth towards the end of the world. Some place his capital at Constantinople, others at Jerusalem, others at Moscow, and some few at London; but the generality at Rome, though these last are divided. Grotius and some others suppose Rome Pagan to have been the seat of Antichrist; most of the Lutheran and reformed doctors contend earnestly for Rome Christian under the papal hierarchy. In fact, the point having been maturely debated at the council of Gap, held in 1603, a resolution was taken thereupon to insert an article in the Confession of Faith, whereby the pope is formally declared to be Antichrist. Pope Clement VIII. was stung to the quick with this decision; and even King Henry IV. of France was not a little mortified to be thus declared, as he said, an imp of Antichrist.

M. Leclerc holds that the rebel Jews and their leader Simon, whose history is given by Josephus, are to be reputed as the true Antichrist. Lightfoot and Vanderhart rather apply this character to the Jewish Sanhedrim. Hippolitus and others held that the devil himself was the true Antichrist; that he was to be incarnate, and make his appearance in human shape before the consummation of all things. Others among the ancients held that Antichrist was to be born of a virgin by some prolific power imparted to her by the devil.

Hunnius and some others assert that there is to be both an eastern and a western Antichrist. Father Malvenda, a Jesuit, published a large work entitled *Antichristo*, in which this subject is amply discussed.

Upon the whole, the Antichrist mentioned by the apostle John in his First Epistle, ii. 18, and more particularly described in the book of Revelation, seems evidently to be the same with the *Man of Sin*, &c. characterized by St Paul in his Second Epistle to the Thessalonians, chap. ii.; and the entire description literally applies to the excesses of papal power. Had the right of private judgment, says an excellent writer, been always adopted and maintained, Antichrist could never have been; and when that sacred right comes to be universally asserted, and men follow the voice of their own reason and conscience, Antichrist can be no more.

ANTICHRISTIANISM, a state or quality in persons or principles which denominates them antichristian, or opposite to the kingdom of Christ. M. Jurieu takes the idea of the unity of the church to have been the source of *Antichristianism*. Had not mankind been infatuated with this, they would never have stood in such awe of the anathemas of Rome. It is on this that the popes erected their monarchical power.

ANTICHTHONES, in *Ancient Geography*, an appellation given to the inhabitants of opposite hemispheres.

ANTICOSTE, a barren island lying in the mouth of the river St Lawrence, in North America. Long. 64. 16. W. Lat. 49. 40. N.

ANTIDICOMARIANITES, ancient heretics who pretended that the Holy Virgin did not preserve a perpetual virginity, but that she had several children by Joseph after our Saviour's birth.

ANTIDORON, in ecclesiastical writers, a name given by the Greeks to the consecrated bread, out of which the middle part, marked with the cross, wherein the consecration resides, being taken away by the priest, the remainder is distributed after mass to the poor. On the sides of the antidoron are impressed the words *Jesus Christus vicit.* The word is formed from δωρον, *donum*, a gift, as being given away *loco muneris*, or in charity. The antidoron is also called *panis præsanctificatus.*

ANTIDOSIS, in *Antiquity*, denotes an exchange of estates, practised by the Greeks on certain occasions with peculiar ceremonies, and first instituted by Solon.

When a person was nominated to an office, the expense of which he was not able to support, he had recourse to the antidosis; that is, he was to seek some other citizen of better substance than himself, who was free from this and other offices; in which case the former was excused. In case the person thus substituted denied himself to be the richest, they were to exchange estates after this man-

Antigonus. ner: the doors of their houses were shut up and sealed, that nothing might be conveyed away; then both took an oath to make a faithful discovery of all their effects, except what lay in the silver mines, which by the laws were exempted from all imposts. Accordingly, within three days, a full discovery and exchange of estates was made.

ANTIGONUS I., one of the captains of Alexander the Great, was the son of Philip, a Macedonian nobleman. After Alexander's death, a division of the provinces taking place, Pamphylia, Lycia, and Phrygia Major fell to his share. But Perdiccas, well acquainted with his ambitious spirit and great abilities, determined to divest him of his government, and laid plans for his life, by bringing various accusations against him. Antigonus, aware of the danger, retired with his son Demetrius into Greece, where he obtained the favour and protection of Antipater; and in a short time Perdiccas dying, a new division took place, when he was invested not only with the government of the former provinces, but also with that of Lycaonia. He was likewise intrusted with the command of the Macedonian household troops; and upon Eumenes being declared a public enemy, he received orders to prosecute the war against him with the utmost vigour. On the commencement of this war, Eumenes suffered a total overthrow, and was obliged to retire with only 600 brave followers to a castle situated on an inaccessible rock, where he might rest in safety from all the assaults of Antigonus. In the interval, his friends assembled a new army for his relief, which was routed by Antigonus, who now began to exhibit the great projects of his ambition. Polyperchon succeeding to the tutorship of the young king of Macedon after Antipater's death, Antigonus resolved to set himself up as lord of all Asia. On account of the great power of Eumenes, he greatly desired to gain him over to his interest; but that faithful commander, effecting his escape from the fortress where he was closely blockaded, raised an army, and was appointed the royal general in Asia. The governors in Upper Asia co-operating with him, he succeeded in several engagements against Antigonus; but was at last delivered up to him through treachery, and put to death. Upon this the governor of Upper Asia yielded to Antigonus. Those whom he suspected, he either sacrificed to his resentment or displaced from their offices. Then seizing upon all the treasures at Susa, he directed his march towards Babylon, of which city Seleucus was governor. Seleucus fled to Ptolemy, and entered into a league with him, together with Lysimachus and Cassander, with the intention of giving a check to the exorbitant power of Antigonus, who, notwithstanding this, made a successful attempt upon the provinces of Syria and Phœnicia. But these provinces were soon after recovered by Ptolemy, who defeated his son Demetrius, while he himself was employed in repelling Cassander, who had made rapid progress in Lesser Asia. They were again taken by Antigonus, who, being flushed with his success, planned an expedition against the Nabathæan Arabs, dwelling in the deserts adjacent to Judea; but on the first enterprise against the town of Petra, his general Athenæus, with almost all his troops, was cut to pieces by the Arabs. Antigonus then sent his son against them, who returned after forcing them to reasonable terms. Demetrius then expelled Seleucus from Babylon; and success attending his arms wherever he went, the confederates were obliged to make a treaty with Antigonus, in which it was stipulated that he should remain in possession of all Asia, but that the Greek cities should continue in possession of their liberty. This agreement was soon violated, under the pretence that garrisons had been placed in some of these cities by Antigonus. At first Ptolemy made a successful descent into Lesser Asia, and on several of the islands of the Archipelago; but he was at length defeated by the successful arms of Demetrius in a sea-fight, who also took the island of Cyprus, with many prisoners. On this victory Antigonus was so elated that he assumed the title of king, and bestowed the same upon his son; and from that time, B. C. 306, his reign in Asia, and that of Ptolemy in Egypt, and of the other captains of Alexander in their respective governments, properly commence.

Irritated at the hostile conduct of Ptolemy, Antigonus prepared a numerous army and a formidable fleet; and having taken the command of the army, he gave the command of the fleet to Demetrius, and hastened to attack him in his own dominions. After enduring the severest hardships, they met in the vicinity of Mount Cassius; but Ptolemy acted with such valour and address that Demetrius could gain no advantage over him; and after several fruitless attempts, he abandoned the undertaking. He next attempted the reduction of Rhodes; but meeting with obstinate resistance, he was obliged to make a treaty upon the best terms that he could, having been called to join Antigonus against Cassander, who at this time had formed a confederacy with Seleucus and Lysimachus. When Demetrius united his forces with those of Antigonus, they advanced to Phrygia, and having met the enemy at Ipsus, a decisive battle was fought, in which Antigonus fell, in the 84th year of his age, B. C. 301.

ANTIGONUS *Gonatas*, son of Demetrius Poliorcetes, was the grandson of the former Antigonus. His character was eminently distinguished by humanity and mildness of disposition. When he besieged Thebes under the command of his father, he strongly remonstrated against the loss of so many lives for such an insignificant object. Filial affection was so powerful in his mind, that when his father was taken prisoner by Seleucus, he generously offered himself in his stead; and being rejected, he wore deep mourning, and refrained from all festivals and amusements during his father's imprisonment. Informed of his death, all the floods of sorrow burst from his tender heart, and sailing with a fleet to meet his ashes, he received them with all the demonstrations of filial sensibility and dutiful respect. By the death of his father he became master of all the European dominions of Demetrius, together with the kingdom of Macedon, and various other cities in Greece. The Gauls invading his country, he defeated and expelled them; but was soon after routed by Pyrrhus, king of Epirus. Some time after, however, Pyrrhus was slain at Argos; and when his head was brought to him by his son, he expressed the highest displeasure, and throwing his robe over it, he gave orders to search for his body, and to inter the same with all funeral honours.

In the evening of his reign he so cultivated the arts of peace, and so conciliated the minds of his subjects, that he secured their affections both to himself and his descendants. The taking of the citadel of Corinth by intrigue was the meanest action of his reign; but he improved that event in maintaining the freedom of the small estates of Greece, and in increasing his own dominions. The Achæans, and Aratus their famous chief, vigorously opposed his measures, and at length recovered Corinth; but Antigonus was so inclined to peace, that notwithstanding this event, he pursued his wonted plan, and left his kingdom in peace about the 80th year of his life and the 44th of his reign, B. C. 243; and Demetrius II. his son, next ascended the throne.

ANTIGRAPHUS, in *Antiquity*, an officer of Athens, who kept a counterpart of the *apodecti*, or chief treasurer's accounts, to prevent mistakes, and keep them from being falsified.

ANTIGRAPHUS is used by writers in the middle ages for

a secretary or chancellor. He is thus called, according to the old glossarists, on account of his writing answers to the letters sent to his master. The antigraphus is sometimes also called *archigraphus*, and his dignity *antigraphia* or *archigraphia*.

ANTIGRAPHUS is also applied by ecclesiastical writers to an abbreviator of the papal letters; in which sense the word is used by Pope Gregory the Great in his register.

ANTIGUA, one of the Antilles or Caribbee Islands, situated 20 leagues east of St Christophers, in long. 61. 45. W. and lat. 17. 6. N. It is about 50 miles in circumference, and is reckoned the largest of all the British leeward islands. This island having no rivers, and but few springs, or such as are brackish, the inhabitants are obliged to preserve the rain-water in cisterns. The air here is not so wholesome as in the neighbouring islands, and it is more subject to hurricanes; but it has excellent harbours, particularly English Harbour, which is capable of receiving the largest man-of-war in the navy. The principal trade, however, is carried on in the harbour of St Johns, the capital, situated in the north-west part of the island, and which has water sufficiently deep for merchant vessels. The island, according to Edwards, contains 59,838 acres of land, of which about 34,000 are appropriated to the growth of sugar, including those which are annexed as pasture grounds. The other staples are cotton, ginger, and tobacco.

A settlement was first attempted in Antigua by Sir Thomas Warner, about the same time with those in St Christophers and Nevis; but no establishment then took place. It was afterwards granted by Charles II. to Lord Willoughby, then governor of Barbadoes, who settled a colony upon it in the space of a few years. The imports in 1810 amounted to L.285,000, and the exports to L.182,000. According to Young (*West India Common-Place Book*), the population is 40,000, of whom 36,000 are slaves; but the free population has increased, and the negroes diminished, since his work was published. See Malte-Brun's *Geography*, vol. v. p. 588–9 (English translation).

ANTIGUGGLER is a crooked tube of metal, so bent as easily to be introduced into the necks of bottles, and used in decanting liquors without disturbing them.

ANTILLES, the French name for the Caribbee Islands.

ANTILOGARITHM, the complement of the logarithm of a sine, tangent, or secant; or the difference of that logarithm from the logarithm of 90 degrees.

ANTILOGY, in matters of literature, an inconsistency between two or more passages of the same book.

ANTIMENSIUM, a kind of consecrated table-cloth, occasionally used in places where there is no proper altar.

ANTIMENSIUM, in the Greek church, answers to the *altare portabile*, or portable altar, in the Latin church. They are both only of late invention, though Habertus would have them as old as St Basil. But Durant and Bona do not pretend to find them in any author before the time of Bede and Charlemagne.—*Antimensia* is also applied to other tables used in offices of religion, besides those whereon the eucharist is administered: such, *e. g.* are those whereon the host is exposed, &c.

ANTIMERIA, in *Grammar*, a figure whereby one part of speech is used for another: e. g. *velle suam cuique est*, for *voluntas sua cuique est*; also *populus late rex*, for *populus late regnans*.

ANTIMERIA, in a more restrained sense, is a figure where the noun is repeated instead of the pronoun. The antimeria is frequent in the Hebrew, and is sometimes retained in our version of the Old Testament accordingly: e. g. *Hear my voice, ye wives of Lamech*, for *my wives*, Gen. iv. 23.

ANTIMETABOLE, in *Rhetoric*, a figure which sets two things in opposition to each other. The word is Greek, compounded of *αντι*, *against*, and *μεταβολη* from *μεταβαλλω*, *I shift* or *transfer*, *i. e.* shifting, or setting two things over against each other. Antimetabole || Antinomians.

ANTIMETATHESIS, in *Rhetoric*, is the inversion of the parts or members of an antithesis. Such is that of Cicero in Verrem, lib. iv. cap. 52: "Compare this peace with that war; the arrival of this governor with the victory of that general; his profligate troops with the invincible army of the other; the luxury of the former with the temperance of the latter: you will say that Syracuse was founded by him who took it, and taken by him who held it when founded."

ANTIMONY, a blackish mineral substance, staining the hands, full of long, shining, needle-like striæ, hard, brittle, and considerably heavy. It is found in different parts of Europe, as Bohemia, Saxony, Transylvania, Hungary, France, and England; commonly in mines by itself, intermixed with earth and stony matters. Sometimes it is blended with the richer ores of silver, and renders the extraction of that metal difficult, by volatilizing a part of the silver, or, in the language of the miners, *robbing the ore*. Antimony is the *stibium* of the ancients; by the Greeks called *στιμμι*. The reason of its modern denomination, *antimony*, is usually referred to Basil Valentine, a German monk, who, as the tradition relates, having thrown some of it to the hogs, observed that, after purging them violently, they immediately grew fat upon it. This made him think, that by giving his fellow-monks a like dose, they would be the better for it. The experiment, however, succeeded so ill, that they all died of it; and the medicine thenceforward was called *antimony*, q. d. *anti-monk*. Antimony at first was used only in the composition of paint. Scripture describes it as a sort of paint with which the women blackened their eyebrows. Its modern uses are very numerous and important. It is a common ingredient in specula or burning concaves, serving to give the composition a finer texture. It makes a part in bell-metal, and renders the sound clearer. It is mingled with tin to make it harder, whiter, and more sonorous; and with lead, in the casting of printers' letters, to render them smoother and firmer. It is also a general help in the melting of metals, and especially in the casting of cannon-balls. It is likewise made use of for purifying and heightening the colour of gold. For a long time this mineral was esteemed poisonous. In 1566 its use was prohibited in France by an edict of parliament; and in 1609 one Besnier was expelled the faculty for having administered it. The edict was repealed in 1650, antimony having a few years before been received into the number of purgatives. In 1668 a new edict came forth, forbidding its use by any but doctors of the faculty. It is now universally allowed that pure antimony in its crude state has no noxious quality, and that though many of its preparations are most virulently emetic and cathartic, yet, by a slight alteration or addition, they lose their virulence, and become mild in their operation. Its virtues in the diseases of animals are greatly extolled.

ANTINOEIA, in *Antiquity*, annual sacrifices and quinquennial games in memory of Antinous the Bithynian. They were instituted at the command of Adrian, the Roman emperor, at Mantinea in Arcadia, where Antinous was honoured with a temple and divine worship.

ANTINOMIANS, in *Ecclesiastical History*, certain heretics who maintain that the law is of no use or obligation under the gospel dispensation, or who hold doctrines that clearly supersede the necessity of good works and a virtuous life. The Antinomians took their origin from John Agricola about the year 1538, who taught that the law is

Antinous il Antioch.

nowise necessary under the gospel; that good works do not promote our salvation, nor ill ones hinder it; that repentance is not to be preached from the decalogue, but only from the gospel.

This sect sprung up in England during the protectorate of Oliver Cromwell, and extended their system of libertinism much farther than Agricola, the disciple of Luther. Some of their teachers expressly maintained, that as the elect cannot fall from grace, nor forfeit the divine favour, the wicked actions they commit are not really sinful, nor are to be considered as instances of their violation of the divine law; and that, consequently, they have no occasion either to confess their sins or to break them off by repentance. According to them, it is one of the essential and distinctive characters of the elect, that they cannot do any thing which is either displeasing to God or prohibited by the law.

The doctrine of Agricola was in itself obscure, and perhaps represented worse than it really was by Luther, who wrote with acrimony against him, and first styled him and his followers *Antinomians*. Agricola stood on his own defence, and complained that opinions were imputed to him which he did not hold. Nicholas Amsdorf fell under the same odious name and imputation, and seems to have been treated more unfairly than even Agricola himself.

ANTINOUS, the favourite of Adrian, was born at Bithynus in Bithynia. His beauty engaged the heart of Adrian in such a manner, that there never was a more boundless and extravagant passion than that of this emperor towards this youth. After his death the emperor ordered divine honours to be paid him, and he also erected a city which he named after him.

ANTIOCH, a city of Syria, in Asia, situated on the river Orontes, in long. 36. 5. E. lat. 36. 10. N. It was built by Seleucus Nicator, founder of the Syro-Macedonian empire, who made it his capital. It stood on the above-mentioned river, about 20 miles from the place where it falls into the Mediterranean, being equally distant from Constantinople and Alexandria in Egypt, that is, about 700 miles from each. Seleucus called it *Antioch*, from his father's name according to some, or from that of his son according to others. He built sixteen other cities bearing the same name, of which one, situated in Pisidia, is probably that where the name of Christians was first given to the followers of Jesus Christ. But that situated on the Orontes by far eclipsed not only all the others of this name, but all the cities built by Seleucus. Antigonus, not long before, had founded a city in that neighbourhood, which from his own name he had called Antigonia, and designed it for the capital of his empire; but it was razed to the ground by Seleucus, who employed the materials in building his metropolis, and also transplanted the inhabitants thither.

Antioch was afterwards known by the name of Tetrapolis, being divided as it were into four cities, each surrounded with its proper wall, besides a common one which inclosed the whole. The first of these cities was built by Seleucus Nicator, as already mentioned; the second by those who flocked thither on its being made the capital of the Syro-Macedonian empire; the third by Seleucus Callinicus; and the fourth by Antiochus Epiphanes. About four or five miles distant stood a place called Daphne, which was nevertheless reckoned a suburb of Antioch. Here Seleucus planted a grove, and in the middle of it built a temple, which he consecrated to Apollo and Diana, making the whole an asylum. To this place the inhabitants of Antioch resorted to indulge in amusements and impure pleasures, by which it became at last so infamous, that "to live after the manner of Daphne" was used as a proverb to express the most voluptuous and dissolute life.

Though Antioch continued to be, as Pliny calls it, the queen of the East, for near 1600 years, yet scarcely any city mentioned in history has undergone such calamities, both from the attacks of its enemies, and its being in a remarkable degree subject to earthquakes. The first disaster mentioned in history which befell the Antiochians happened about 145 years before Christ. Being at that time very much disaffected to the person and government of Demetrius their king, they were continually raising tumults and seditions. Wearied with their turbulence, he at last solicited assistance from the Jews, and was furnished by Jonathan, one of the Maccabees, with 3000 men. With this reinforcement believing himself sufficiently strong to reduce the mutineers by force, he ordered them immediately to deliver up their arms. This unexpected order caused a great uproar in the city. The inhabitants ran to arms and invested the king's palace, to the number of 120,000, with a design to put him to death. All the Jews hastened to his relief, fell upon the rebels, killed 100,000 of them, and set fire to the city. On the destruction of the Syrian empire by the Romans, Antioch submitted to them, and continued for a long time under their dominion. About the year 115, in the reign of the emperor Trajan, it was almost entirely ruined by one of the most dreadful earthquakes mentioned in history. Trajan himself happened to be there at the time, on his return from an expedition against the Parthians; so that the city was then full of troops and strangers from all quarters, either out of curiosity or upon business and embassies. The calamity was consequently felt almost in every province of the Roman empire. The earthquake was preceded by violent claps of thunder, unusual winds, and a dreadful noise under ground. The shock was so terrible, that great numbers of houses were overturned, and others tossed to and fro like a ship at sea. Those who happened to be in their houses were for the most part buried under their ruins; those who were walking in the streets or in the squares were, by the violence of the shock, dashed to the ground, and most of them either killed or dangerously wounded. The earthquake continued, with some small intermission, for several days and nights. Trajan was much hurt, but escaped through a window. As an eyewitness of this terrible calamity, he would very probably contribute largely towards the re-establishment of Antioch in its ancient splendour. Its good fortune, however, did not continue long; for in 155 it was almost entirely burnt by accidental fire, when it was again restored by Antoninus Pius.

When the Roman empire began to decline, Antioch became a bone of contention between it and the eastern nations; and accordingly, on the breaking out of a Persian war, it was almost always sure to suffer. In 242 it was taken and plundered by Sapor; and though he was defeated by Gordian, it underwent the same misfortune in the time of Valerian, about 18 years after; and subsequently to the defeat and captivity of Valerian, being taken by the Persian monarch a third time, he not only plundered it, but levelled all the public buildings with the ground. The Persians, however, being soon driven out, this unfortunate city continued free from any remarkable calamity till about the time of the division of the Roman empire by Constantine in 331. It was then afflicted with so terrible a famine, that a bushel of wheat was sold for 400 pieces of silver. During this grievous distress, Constantine sent to the bishop 30,000 bushels of corn, besides an immense quantity of all kinds of provisions, to be distributed among the ecclesiastics, widows, orphans, &c. In the year 347 Constantine II. caused a harbour to be made at Seleucia, for the conveniency of Antioch. This was effected at great expense; the mouth of the Orontes, where the

port was made, being full of sands and rocks. When the emperor Julian set out on his expedition against the Persians, he made a long stay at Antioch, which then suffered severely from a famine. In 381, in the reign of Theodosius the Great, Antioch was again visited by a famine, accompanied by a grievous plague. In 387 Theodosius, finding his exchequer quite drained, and being obliged to be at an extraordinary expense in celebrating the fifth year of the reign of his son Arcadius, and the tenth of his own, an extraordinary tax was laid upon all the people in the empire. Most of the cities submitted willingly to this; but the people of Antioch assailed their governor, broke some of the emperor's statues, and dragged others through the city, uttering the most injurious and abusive expressions against him and his whole family. They were dispersed by a body of archers, and the governor proceeded against the offenders with the utmost cruelty, exposing some to wild beasts in the theatre, and burning others alive. Many fled from the city and never returned. On hearing the news of the tumult, Theodosius was so much enraged that he commanded the city to be destroyed, and its inhabitants to be put to the sword without distinction; but this order was revoked before it could be put into execution, and he contented himself with inflicting severe punishments on individuals. In the year 458 Antioch was again almost entirely ruined by an earthquake, which happened on the 14th of September; scarcely a single house being left standing in the most beautiful quarter of the city. It experienced a similar misfortune in 529, during the reign of the emperor Justin; and in 15 years after, being taken by Chosroes, king of Persia, that insulting and haughty monarch gave it up to his soldiers, who put all they met to the sword. The king himself seized on all the gold and silver vessels belonging to the great church, and caused all the valuable statues, pictures, &c. to be taken down and conveyed to Persia, while his soldiers carried off every thing else. The city being completely plundered, he ordered his men to set fire to it; and this was done so effectually, that none of the buildings even without the walls escaped. Such of the inhabitants as escaped slaughter were carried into Persia and sold as slaves. The city, however, was again restored, but in a short time underwent its usual fate, being almost entirely destroyed by an earthquake in 587, by which 30,000 persons lost their lives. In 634 it fell into the hands of the Saracens, who kept possession of it till the year 858, when it was surprised by one Burtzas, and again annexed to the Roman empire. The Romans continued masters of it for some time, till the civil dissensions in the empire gave the Turks an opportunity of mastering it, as well as the whole kingdom of Syria. From them it was again taken by the crusaders in 1098. In 1262 it was again taken by Bibaris, sultan of Egypt, who put a final period to its glory.

Antioch, called by the Arabs *Antakia*, is now a ruinous town, whose houses, built with mud and straw, and narrow and miry streets, exhibit every appearance of misery and wretchedness. These houses are situated on the southern bank of the Orontes, at the extremity of an old decayed bridge: they are covered to the south by a mountain, upon the slope of which is a wall built by the crusaders. The distance between the present town and this mountain may be about 400 yards, which space is occupied by gardens and heaps of rubbish, but presents nothing interesting. Antioch was better calculated than Aleppo to be the emporium of the Europeans. By clearing the mouth of the Orontes, which is six leagues lower down, boats might have been towed up that river, though they could not have sailed up, as Pococke has asserted, its current being too rapid. The natives, who never knew the name Orontes, call it, on account of the swiftness of its stream, *El Aasi*, that is, the rebel. Its breadth at Antioch is about forty paces. Seven leagues above that town it passes by a lake abounding in fish, and especially in eels. A great quantity of these are salted every year, but not sufficient for the numerous fasts of the Greek Christians. The plain of Antioch, though the soil of it is excellent, is uncultivated, and abandoned to the Turcomans; but the hills on the side of the Orontes, particularly opposite Serkin, abound in plantations of figs and olives, vines and mulberry trees. Seleucus Nicator, who founded Antioch, built also at the mouth of the Orontes, on the northern bank, a large and well-fortified city, which bore his name, but of which at present not a single habitation remains; nothing is to be seen but heaps of rubbish, and works in the adjacent rock, which prove that this was once a place of very considerable importance. In the sea also may be perceived the traces of two piers, which are indications of an ancient port, now choked up. The inhabitants of the country go thither to fish, and call the place *Souaidia*. Antioch is situate in long. 37. 5. E. and lat. 36. 20. N.

ANTIOCHIAN Sect or Academy, a name given to what was called the fifth academy. It took the denomination from its being founded by Antiochus, a philosopher contemporary with Cicero. The Antiochian academy succeeded the Philonian. As to doctrine, the philosophers of this sect appear to have restored that of the ancient academy, except in the article of the criterion of truth. Antiochus was really a Stoic, and only nominally an Academic.

Antiochian Epocha, a method of computing time from the proclamation of liberty granted to the city of Antioch about the time of the battle of Pharsalia.

ANTIOCHUS of *Ascalon*, a celebrated philosopher, the disciple of Philo of Larissa, the master of Cicero and the friend of Lucullus and Brutus. He was founder of a fifth academy. See Antiochian Sect.

ANTIOPE, in fabulous history, the wife of Licus, king of Thebes, who being deflowered by Jupiter in the form of a satyr, brought forth Amphion and Zethus. Another Antiope was queen of the Amazons, and, with the assistance of the Scythians, invaded the Athenians, and was vanquished by Theseus.

ANTIPÆDOBAPTISTS, (derived from *αντι*, *against*, *παις*, *παιδος*, *child*, and *βαπτιζω*, *I baptize*, whence *βαπτιστης*), is a distinguishing denomination given to those who object to the baptism of infants; because they say infants are incapable of being instructed, and of making that profession of faith which entitles them to this ordinance, and an admission into church communion.

ANTIPAROS, an island in the Archipelago, opposite to Paros, from which it is separated by a strait about seven miles over. It is the *Oleares* or *Oliaros* mentioned by Strabo, Pliny, Virgil, Ovid, &c.; and was, according to Heraclides Ponticus, as quoted by Stephanus, first peopled by a Phœnician colony from Sidon. According to Mr Tournefort's account, it is about 16 miles in circumference, and tolerably fertile.

This island is remarkable for a subterraneous cavern or grotto, accounted one of the greatest natural curiosities in the world. It is 300 fathoms below the surface of the earth, and appears to be about 40 fathoms high and 50 wide, penetrating far into the bosom of the island. It is full of large and beautiful stalactites. There have been many descriptions of this celebrated grotto, of which that by Tournefort is supposed to be very complete and exact. (*Relation d'un Voyage du Levant.*)

ANTIPAS Herod, or Herod-Antipas, the son of Herod the Great, by one of his wives called Cleopatra, a

native of Jerusalem. Herod the Great, in his first will, appointed Antipas his successor in the kingdom; but afterwards altering that will, he named his son Archelaus his successor, giving to Antipas the title only of tetrarch of Galilee and Peræa.

Antipas took a great deal of pains in adorning and fortifying the principal places of his dominions. He married the daughter of Aretas king of Arabia, whom he divorced about the year of Christ 33, to marry his sister-in-law Herodias, wife to his brother Philip, who was still living. St John the Baptist exclaiming continually against this incest, was, by order of Antipas, imprisoned in the castle of Machærus. Josephus says that Antipas caused St John to be laid hold of because he drew too great a concourse of people after him; and that he was afraid lest he should make use of the authority which he had acquired over the minds and affections of the people to induce them to revolt. But the evangelists, who were better informed than Josephus, as being eye-witnesses of what passed, and acquainted in a particular manner with St John and his disciples, assure us that the true reason of imprisoning St John was the aversion which Herod and Herodias had conceived against him for the liberty he had used in censuring their scandalous marriage. The virtue and holiness of St John were such that even Herod feared and respected him; but his passion for Herodias would have induced him to kill that prophet, had he not been restrained by his apprehensions of the people, who esteemed John the Baptist as a prophet. (Matt. xiv. 5, 6.) One day, however, while the king was celebrating the festival of his birth with the principal persons of his court, the daughter of Herodias danced before him, and pleased him so well, that he promised with an oath to give her whatever she should ask of him. By her mother's advice she asked the head of John the Baptist; upon which the king commanded John to be beheaded in prison, and the head to be given her. Aretas, king of Arabia, to revenge the affront which Herod had offered to his daughter, declared war against him, and overcame him in a very obstinate engagement. Herod being afterwards detected as a party in Sejanus's conspiracy, was banished by the emperor Caius to Lyons in Gaul, whither Herodias accompanied him. The time when he died is not known; however, it is certain he died in exile, as well as Herodias.

ANTIPATER, the disciple of Aristotle, and one of Alexander the Great's generals, was a man of great abilities, and a lover of the sciences; but was accused of poisoning Alexander. He subdued the revolted Thracians, relieved Megalopolis, and overthrew the Spartans there. He died 321 years before the Christian era.

Antipater, an Idumean of illustrious birth, and possessed of great riches and abilities, taking advantage of the confusion into which the two brothers Hyrcanus and Aristobulus plunged Judea by their contest for the office of high priest, took such measures as to gain for Hyrcanus that office, and under his government to obtain the absolute direction of all affairs; while his great abilities and application to business made him so considerable, that he was honoured as much as if he had been invested with the royal authority in form: but he was at last poisoned by a Jew named Malachus, 43 years before the Christian era. He left, among his other children, the famous Herod, king of the Jews.

Antipater, *Cælius*, a Roman historian, who wrote a history of the Punic war, much valued by Cicero. The emperor Adrian preferred him to Sallust.

Antipater of Sidon, a Stoic philosopher, and likewise a poet, commended by Cicero and Seneca. He flourished about the 171st Olympiad. We have several of his epigrams in the *Anthologia*.

ANTIPATHY, in *Physiology*, is formed from the two Greek words, αντι, *contrary*, and παθος, *passion*. Literally taken, the word signifies *incompatibility*: but for the most part the term *antipathy* is not used to signify such incompatibilities as are merely physical; it is reserved to express the aversion which an animated or sensitive being feels at the real or ideal presence of particular objects. In this point of view, which is the light in which we at present consider the term, *antipathy*, in common language, signifies a natural and involuntary aversion which a sensitive being feels for some other object, whatever it is, though the person who feels this abhorrence is entirely ignorant of its cause, and can by no means account for it. Such is, they say, the natural and reciprocal hostility between the toad and the weasel, between sheep and wolves. Such is the invincible aversion of particular persons against cats, mice, spiders, &c., a prepossession which is sometimes so violent as to make them faint at the sight of these animals. To explore the matter without prejudice, we shall find it necessary to abstract from this disquisition all such antipathies as are not ascertained, as that which is supposed to be felt between the salamander and tortoise, and between the weasel and the toad. We must abstract those which can be extinguished or resumed at pleasure; those fictitious aversions which only certain persons feel or pretend to feel. When we abstract aversions, the causes of which are known and evident, we shall be surprised, after deduction of pretended antipathies, how small, how inconsiderable, is the quantity of those which are conformable to our definition. Will any one pretend to call by the name of *antipathy* those real, innate, and incontestable aversions which prevail between sheep and wolves? Their cause is obvious: the wolf devours the sheep, and subsists upon his victims; and every animal naturally flies with terror from pain or destruction: sheep ought therefore to regard wolves with horror, which, for their nutrition, tear and mangle the unresisting prey. From principles similar to this arises that aversion which numbers of people feel against serpents, against small animals, such as reptiles in general, and the greater number of insects. During the credulous and susceptible period of infancy, pains have been taken to impress on our minds the frightful idea that they are venomous; that their bite is mortal; that their sting is dangerous, productive of tormenting inflammations or tumours, and sometimes fatal: they have been represented to us as ugly and sordid; as being for that reason pernicious to those who touch them; as poisoning those who have the misfortune to swallow them. Is it then wonderful (if our false impressions as to this subject have been corrected neither by future reflections nor experiments) that we should entertain during our whole lives an aversion for these objects, even when we have forgot the admonitions, the conversations, and examples, which have taught us to believe and apprehend them as noxious beings? To explain these facts, is it necessary to fly to the exploded subterfuge of occult qualities inherent in bodies, to latent relations productive of antipathies, of which no person could ever form an idea?

To what then are those *antipathies* of which we have heard so much reducible? Either to legendary tales, or to aversions against objects which we believe dangerous, or to a childish terror of imaginary perils, or to a disrelish of which the cause is disguised, or to an infirmity of the stomach,—in a word, to a real or pretended reluctance for things which are either invested or supposed to be invested with qualities hurtful to us. Too much care cannot be taken in preventing or regulating the *antipathies* of children; in familiarizing them with objects of every kind; in discovering to them, without emotion, such as

are dangerous; and in teaching them the means of defence and security, or the methods of escaping their noxious influence.

ANTIPATHY, in *Ethics*, hatred, aversion, repugnancy. *Hatred* is entertained against persons, *aversion* and *antipathy* indiscriminately against persons or things, and *repugnancy* against actions alone.

ANTIPELARGIA, among the ancients, a law whereby children were obliged to furnish necessaries to their aged parents. The ciconia, or stork, is a bird famous for the care it takes of its parents when grown old; hence, in some Latin writers, this is rendered *lex ciconiaria*, or the stork's law.

ANTIPHONARY, ANTIPHONARIUM, a service-book, which contained all the invitatories, responsories, collects, and whatever else was sung or said in the choir, except the lessons. This is otherwise called *responsorium*, from the responses contained therein. The author of the Roman *antiphonary* was Pope Gregory the Great. We also find mention of nocturnal and diurnal *antiphonaries*, for the use of the daily and nightly offices; summer and winter *antiphonaries*; also *antiphonaries* for country churches, &c. By the provincial constitutions of Archbishop Winchelsea, made at Merton A. D. 1305, it is required that one of these should be found in every church within the province of Canterbury. The use of these and many other popish books was forbid by the 3d and 4th of Edward VI. c. 10.

ANTIPHONY, the answer made by one choir to another, when the psalm or anthem is sung between two.

ANTIPHONY sometimes denotes a species of psalmody, wherein the congregation being divided into two parts, repeat the psalms, verse for verse, alternately. In this sense antiphony stands contradistinguished from symphony, where the whole congregation sing together.

Antiphony differs from responsorium, because in this latter the verse is only spoken by one person, whereas in the former the verses are sung by the two choirs alternately. The original of antiphonal singing in the western churches is referred to the time of St Ambrose, about the year 374. That father is said to have first introduced it into the church of Milan, in imitation of the custom of the eastern church, where it appears to be of greater antiquity, though as to the time of its institution authors are not agreed. It was probably introduced at Antioch between the years of Christ 347 and 356.

ANTIPHONY is also used to denote the words given out at the beginning of the psalm, to which both the choirs are to accommodate their singing.

ANTIPHONY, in a more modern sense, denotes a kind of composition made of several verses extracted out of different psalms, adapted to express the mystery solemnized on the occasion.

ANTIPODES, in *Geography*, a name given to those inhabitants of the globe that live diametrically opposite to each other. The word is Greek, and compounded of αντι, *opposite*, and πους, *a foot*, because their feet are opposite to each other. Plato is esteemed the first who thought it possible that antipodes subsisted, and is looked upon as the inventor of the word. As this philosopher apprehended the earth to be spherical, he had only one step to make to conclude the existence of the antipodes. The ancients in general treated this opinion with the highest contempt, never being able to conceive how men and trees could subsist suspended in the air with their feet upwards, for so they apprehended they must be in the other hemisphere. They never reflected that these terms *upwards* and *downwards* are merely relative, and signify only nearer to, or farther from, the centre of the earth, the common centre to which all heavy bodies gravitate; and that, therefore, our antipodes have not their feet upwards and head downwards any more than ourselves, because they, like us, have their feet nearer the centre of the earth, and their heads farther from it. To have the head downwards and feet upwards, is to place the body in a direction of gravity tending from the feet to the head; but this cannot be supposed with regard to the antipodes, for they, like us, tend toward the centre of the earth in a direction from head to foot.

ANTIQUARE, among Roman lawyers, properly denotes the rejecting of a new law, or refusing to pass it. In which sense *antiquating* differs from *abrogating*, as the latter imports the annulling of an old law, the former the rejecting of a new one.

ANTIQUARII, a name given to copiers of old books. After the decline of learning among the Romans, and when many religious houses were erected, learning was chiefly in the hands of the clergy, the greater number of whom were regulars, and lived in monasteries. In these houses were many industrious men, who were continually employed in making new copies of old books, either for the use of the monastery or for their own emolument. These writing monks were distinguished by the name of *Antiquarii*.

ANTIQUARY, a person who studies and searches after monuments and remains of antiquity, as old medals, books, statues, sculptures, and inscriptions, and, in general, all curious pieces that may afford any light into antiquity. In the chief cities of Greece and Italy there were persons of distinction called *antiquaries*, whose business it was to show strangers the antiquities of the place, to explain the ancient inscriptions, and to give them all the assistance they could in this way of learning. Pausanias calls these antiquaries Εξηγηται. The Sicilians call them *mystagogi*.

ANTIQUARY is also used by ancient writers for the keeper of the antiquarium or cabinet of antiquities. The officer is otherwise called *archæota*, or antiquary of a king, a prince, a state, or the like. Henry VIII. gave John Leland the title of his *antiquary*.

ANTIQUE, in a general sense, something that is ancient: but the term is chiefly used by sculptors, painters, and architects, to denote such pieces of their different arts as were made by the ancient Greeks and Romans. Thus we say, an antique bust, an antique statue, &c.

ANTIQUE is something contradistinguished from *ancient*, which signifies a less degree of antiquity. Thus antique architecture is frequently distinguished from ancient architecture.

ANTIQUITIES.

ETYMOLOGISTS derive the word antiquities, and many other kindred words, from an obvious source, the Latin preposition *ante*, before. The great arbiter of language, custom, has ordained that it should mark out and relate to periods of time, not immediately, but long before the days of those who make use of it.

The early records and older monuments of every nation, of whatever kind they may be, may properly be named antiquities; but this term ordinarily calls up in the mind the one or the other of the two grand divisions into which the practice of the learned has long continued to separate so much of the wide field as has hitherto

Antiquities. been carefully cultivated. It either awakens the recollections of the Greeks and the Romans, who are commonly known by the designation of the ancients, and of some other nations, who are remembered chiefly on account of their connection with them, and points out the *antiquities of the scholar*, which are often described by the Greek appellation, archæology; or it reminds us of the history of our ancestors, and of the other European people in the middle ages, which forms the *antiquities of the antiquary*. We are anxious to mark strongly the distinction between archæology, or the study of the Grecian and Roman antiquities, and the study of the antiquary,—the antiquities of the middle ages and of times subsequent. The former pursuit it is scarcely possible to carry to an improper excess, because we may derive advantage and improvement from almost every department of the studies of the archæologist,—so admirable were the institutions of Greece and Rome, and to such a wonderful pitch did the cultivation of the human intellect attain, especially in Greece. But in the middle ages, on the contrary, there was little peculiar of which human nature ought not to be ashamed; and whatever we would not wish to unlearn as to those barbarous times, we would only consent to remember for the purpose of avoiding it in future. It is not to be denied, however, that even in the darkest and rudest of those days of barbarism, several useful and agreeable institutions existed, the loss of which we have abundant cause to deplore, and to regret that they were swept away by ignorant and bigoted men, who, under the specious pretence of reformation, destroyed much that was valuable; yet it is certain—and to those who are well read in the history of classical antiquity the proofs of the assertion are sufficiently familiar—that the institutions which shed a light (if it were but a dim one, it was still a comfort and a guide in a period of darkness, and the absence of it has left a void in society) were not the offspring of the middle ages, but were precious relics still remaining, vestiges still unobliterated, ruins still standing, of older and better times—the creations of the wisdom and virtue of the ancient world. The antiquities of the middle ages, so far as they are the peculiar productions of those ages, are not wanting in good taste alone—that is a defect comparatively of trifling importance, and it might more easily be pardoned; but they are deficient in a good spirit also. This is undeniably a more serious charge, a more grievous deficiency: they are devoid of a patriotic, a benevolent, a humane intention; they are manifestly without the purpose of benefiting the many, of bringing profit to the people at large, of working the good of mankind in general; they seek to aggrandize some feudal tyrant, it may be sometimes a petty tyrant, but still a tyrant—to fasten the yoke upon the neck of the vassal—to add another link to his chain; not, like the happier institutions of earlier and better times, to instruct and gladden the citizen of a free state. It is chiefly on account of this important and remarkable distinction that we give the preference to the study of archæology over the more vulgar and more modern study of what are most commonly denominated antiquities. We will not affect, however, to be insensible to the superior allurements of the former pursuit, or to be ignorant of the intrinsic excellence in all other respects of the relics of ages of extraordinary refinement.

The consideration of these precious relics is not to be undertaken without difficulty. Their number and variety would perplex any one who entered upon the delicate office of explaining them, even if their nature and uses were as obvious in all instances as they are obscure and mysterious in many, and if the space that was afforded for explanation were as unlimited as on the present occasion, from the miscellaneous composition of the publication in which it finds a place, it is necessarily confined. Not only are the remains themselves numerous and almost infinite, but the works in which they have been represented in figures, or described in words, are so bulky and numberless, that it is not only impossible to give a detailed account of them, but it would be vain to endeavour to enumerate each individual. We must content ourselves, therefore, with arranging the vast subject under several heads, with treating briefly and in general terms of each, and with allowing ourselves to dwell a short time, as an indulgence, on one or two matters that appear in our eyes to be of paramount importance.

If it were possible to explain fully and in a satisfactory manner all the monuments of antiquity that are at present known, the subject would not be exhausted. Every year brings important additions to the large stock of antiques; and the exposition of them, like the study of nature, in consequence of new discoveries, is infinite and inexhaustible. The learned Montfaucon, after much experience, expresses, in these remarkable words, his sense of the labours of an archæologist, which appear to terminate only that they may commence again: "Il n'est guère de matière si vaste que celle des monumens de l'antiquité. On voit tous les jours sortir de l'obscurité quelque chose de singulier, et qui n'avoit pas encore été remarqué. Lorsqu'on croit finir ses recueils, on est souvent obligé de recommencer sur nouveaux frais: à peine a-t-on achevé un ouvrage, que des matériaux se présentent pour un autre. La terre en cache une infinité que le pur hazard fait découvrir. On en déterre dans les champs, on en trouve dans les villes: quand on se flatte d'avoir épuisé tous les cabinets, il en sort encore de nouveaux, inconnus quelquefois même à ceux qui les possèdent. Presque toutes les parties de l'Europe en fournissent: le Levant et l'Egypte nous en envoient très souvent et de fort curieux; et ce qui surprend davantage il s'en est rencontré, qui exposés depuis plusieurs siècles à la vue de tout le monde, ont demeuré aussi inconnus que s'ils avoient été cachés en terre, jusqu'à ce que la réflexion nous les a fait estimer ce qu'ils valent."

The productions of the fine arts occupy a distinguished place among the remains of antiquity; and as these generally are closely connected with the pagan religion, it will be necessary to premise a few observations respecting the worship of Greece and Rome.

Men of learning, after the most laborious investigation and study of the ancient religion, have usually come to the conclusion that it is a profound and impenetrable mystery, and that such it was in the time of Cicero, and as far back as the earliest records extend. All the explanations that have hitherto been given are equally unsatisfactory, the astronomical not less so than the rest. Meanwhile the beauty of the mythology is undoubted; it is like nature, for whose wonderful operations the modern theories will not account better than the ancient, while the excellence of her works cannot be denied or questioned. It was a collection of fables from all countries, but it had one characteristic unity, the unity of beauty, and was admirably adapted to the wants of the imagination, and to satisfy the craving of the fancy in human beings of every age and rank. To admit that all of its creations are allegorical, is equally impossible as to deny that some are. This solution indeed ought to be applied sparingly: a good allegory is no doubt satisfactory, but an indifferent one is scarcely tolerable, and nothing is more tiresome and offensive than allegory long sustained or frequently repeated. Theorists have used this key with much confidence, and have sought to lay open by its assistance the sense of the ancient mysteries

Each department of mythology has been exposed in its turn to their fruitless attempts, and the origin of the twelve signs of the zodiac has been a favourite point of inquiry. Every speculator has found in them a confirmation of his own views, a theory after his own heart, plainly written in the heavens in legible and indelible characters, to unfold to mankind matters of very different natures, and of very unequal importance;—a complete development, as some assert, of the foundation of every mode of religious faith, or a plan of diet, as others affirm, so salubrious as to obviate the possibility of disease in the human frame, or of moral evil and consequent misery in the mind of man.

We may enumerate amongst mythic curiosities the French notion, version, or recension, of the ancient mythology, which we see exemplified in their poetry, in their statues and paintings, and in innumerable engravings, but perhaps most perfectly and fully on the French stage, and especially in the ballets which follow the opera. It is a fantastic, affected, insipid, and strange thing, perfectly unlike the original, of which, with a marvellous credulity, an acute and sceptical nation firmly believes that it is a faithful imitation. The French have the merit of affording great encouragements to the study of antiquity, but unhappily they have no feeling for the true antique: they want every quality that is required for comprehending it, and possess all those that can impede the pursuit. They want, in short, nature, ease, grace, and simplicity.

The pagan religion was addressed to the imagination and the feelings, and not to the understanding, from which no submission was required: it sought only to amuse and delight, not to convince. If the forms of the gods were sometimes whimsical,—if strange actions were sometimes attributed to them,—we are told that the object was to attract attention, which ever has been, and ever will be, not less difficult than desirable. The modern practice of endeavouring to obtain hearers by scolding has been found, and ought to be acknowledged, as equally unpleasant and inefficient. Innumerable passages will occur to the scholar, especially in the writings of Cicero, to show that the influence of superstition did not cramp the understanding of the philosopher,—that it was either a plaything or an engine of state, and a part of the powers of government. There is evidence also, that in much earlier times it was not considered necessary to manifest a very lively faith. Valerius Maximus relates, that in the first Punic war, in days of pristine simplicity and primitive piety, when Publius Claudius was consulting the augurs, on being told that the sacred chickens refused to eat, "Then throw them into the sea," he said, "that if they will not eat, they may drink." If the sacred chickens eat the corn that was placed before them, it was a favourable omen; if they devoured it so greedily as to drop a part, success was certain; if, on the contrary, they refused it, there was mischief in the wind; but if they attempted to fly away on quitting the ivory coop, inevitable destruction was impending. The consultation respected the event of a naval engagement; the profane remark of the consul, therefore, was more apposite: "P. Claudius, bello Punico primo, cum prælium navale committere vellet, auspiciaque, more majorum, petiisset, et pullarius non exire cavea pullos nuntiasset, abjici eos in mare jussit, dicens, Quia esse nolunt, bibant."

Notwithstanding the slight influence which the pagan religion possessed over their thoughts and actions, the higher classes were attached to it; great men were glad to be deified, and their relations considered it an honour and a happiness. It was esteemed formerly as advantageous to have a god, as in Catholic countries it still is to have a saint, in the family. It was not only an addition to the splendour of an illustrious house, but possibly it also gratified the spirit of monopoly, as nothing was required to go out of the family, not even prayers and sacrifices; and, moreover, every kind of favour might be reasonably expected from an uncle a god, or an aunt a goddess. Whatever parts of this religion were mysterious, it is at least clear and indisputable that it was essentially and fundamentally of a popular character, and was totally and entirely designed for the public amusement and gratification: it was a political institution for the education of the people. We cannot be surprised, therefore, that it captivated the multitude, who were well aware that it might have been difficult to bestow so much upon them in any other form; and that it was used as a pretext to cover, not taxes and severe exactions, but large, frequent, and liberal donations from the wealthy to the poor. Among the cheerful ancients, as well as among graver people, the immortal gods were often compelled to furnish a decent excuse to enable men to do without censure whatever they wished: there was this important difference, however, that the religious hypocrisy of the former sought commonly to shelter under the awful sanction of celestial patronage, objects, not of a narrow and selfish, but of a liberal and patriotic nature. Works of art being for the most part public property, were frequently vested in a god or a goddess, as a trustee for the people; religion supplied the means of enjoying the only species of property that can advantageously be enjoyed in common. The temples were in truth the museums in which works of art were preserved and exhibited, and the ancient usage still lingers in countries that have not been reformed, where the churches, although not avowedly, are substantially galleries for the display of the productions of the fine arts. Wherever well-stored libraries and rich collections of paintings and statues, and similar objects of *virtù*, are accessible at all hours to the public, the wants of private persons are greatly diminished. It was not only through these exhibitions, which were constantly present to their eyes, that the people were gratified by the ancient religion,—the occasional and periodical festivals were of frequent recurrence, and were a source of joy and happiness for many ages to all ranks. The subject is an agreeable one: it is pleasant to go back to the enjoyments of the ancient world; and we regret that on the present occasion we are only permitted to allude to this interesting topic. M. de Pauw speaks sensibly of the excellent effects of these festive institutions, in the countries where they were most prevalent. "Au reste, si tous ces petits états de l'Attique avoient leurs vices, ils avoient aussi leurs vertus; et Dicéarque lui-même se loue de l'humanité et de la politesse avec laquelle il avoit été reçu sur toutes les grandes routes de cette contrée. Ensuite il assure que nulle part au monde on ne pouvoit vivre plus agréablement qu'à Athènes; soit qu'on eût de l'argent, soit qu'on n'en eût absolument pas. Les riches, dit-il, peuvent s'y procurer tous les agrémens imaginables, et il-y-a, ajoute-t-il, tant de spectacles, tant de fêtes, tant de jeux, tant de divertissemens, que les citoyens indigens n'y pensent jamais à leur pauvreté." (*Récherches Philosophiques sur les Grecs.*) All who have experienced the opposite condition, who have resided in countries where there are no public entertainments, no festivals, no popular amusements, no holydays, are able to bear testimony, that there wealth can procure for the rich few pleasures, and that the many are reminded of, and never see cause to forget, their indigence. Festivals are very useful to the lower classes, especially in country places, as they tend to check the selfishness of individuals, by which their minds are apt to be cramped, and make them feel that they form a part of a great whole: humanity and politeness are wanting wherever they are discouraged, and an absence of

amusements is sure to generate a brutal and sullen incivility. The cheerfulness and courtesy of the Athenians were the fair fruits of a system of reasonable indulgence; and intellectual culture being generally diffused, caused an extreme toleration of all pursuits and opinions. If the people are enabled to judge of works of art, their critical powers will be engaged and exercised more usefully and agreeably than in scanning the actions of their superiors, which they are unable to estimate correctly. Where no congenial occupation is supplied, every low and ignorant fellow may grow into a sour bigot, and, it may be, into an oracle and a prophet, and in that capacity may imagine that it is his duty to seek to shape the conduct and creed of wiser men according to the misconceptions of his wayward fancy.

It is very desirable that some competent person should undertake to give a plain and faithful account of a religion which has never met with fair treatment from its historians. It indicates a bad taste, to say the least of it, to imitate and repeat the absurd and vehement declamations of the fathers of the Christian church against the gods of the ancients. In their times those deities were dangerous rivals; there is certainly no cause to fear them now. No one can see any reason to apprehend that the world will return again to the old worship. The pope and the archbishop of Canterbury may rest in equal security that they will never receive a short notice either to sacrifice a black heifer to Proserpine, or to vacate their respective palaces and offices; the unpleasant option will never be offered to either. It is a mere waste of words, therefore, to persist in calling the heathen, of whom we have learned so much, blind, and to rail at their gods. A religion which was exempt from sordid rites, and of which the end and object were the gratification and cultivation of the people, at least deserves to have its story told and its fortunes related without scurrility, passion, or prejudice. Persons of good taste will be equally offended, on the other hand, at the attempts that are often made by writers, of more zeal than discretion, to wrest the pagan mythology, and to compel it to seem to consent with the mysteries of the Christian religion. Lord Bacon wisely says, in allusion to such unholy and offensive practices, "But I have interdicted my pen all liberties of this kind, lest I should use strange fire at the altar of the Lord." Nor should that excessive dread of idolatry, which characterizes a barbarous people, find a place in such a work: it is time to discard the absurd notion, that it is impossible to see and admire a beautiful statue without worshipping it—that true piety and a taste for the fine arts are of necessity incompatible.

The admirable Heyné complains of the unnatural and forced hypotheses of mythists, and of their disposition to torture the meaning of the ancient fables, and to pervert them to signify matters that were diametrically opposed to the spirit and sense of antiquity. He at the same time lays down a golden rule, to guide the future historian of mythology; and happy will he be who shall have the good sense and the good fortune to be governed by it. "To compose a plain narrative, representing the primitive form under which each fable has been handed down to us by the first poets and the first artists, and afterwards to show the changes and additions that have been made by later poets and artists." "Il nous manque également pour l'étude dont il est question (the study of antiquity), des traités sur les connoissances accessoires, et surtout, un bon ouvrage sur la fable. Nous avons à la vérité beaucoup d'écrits sur la mythologie; mais je ne sais quel mauvais génie se saisit de tous ceux qui veulent traiter cette matière. Ils commencent par établir quelque hypothèse, d'après laquelle ils cherchent à dénaturer et à forcer le sens des anciennes fables; et aucune de ces hypothèses ne se trouve établie sur l'esprit même de l'antiquité. Il nous faut une mythologie qui ne consiste qu'en un simple récit, qui nous présente la forme primitive sous laquelle chaque fable nous a été transmise par les premiers poëtes et par les premiers artistes. Nous devons connoître aussi les changemens et les additions que les artistes et les poëtes postérieurs y ont faits. La meilleure explication est celle qu'on peut tirer de cette méthode et de cette manière d'exposer les choses, en partant des tems de la première origine des fables, et en les suivant dans les différens changemens qu'elles ont éprouvées."

The inexhaustible quarries of fine marble at Athens, and in other parts of Greece, furnished materials for innumerable statues and other sculptures: many of the most celebrated works were executed in ivory. These, of course, have entirely perished; but of those in marble we are so fortunate as to possess some specimens from the hands of the most renowned artists, and it is universally allowed, that even in their present state, all of them having received more or less injury, they are fully worthy of the fame that has attended on the memory of the great men by whom they were fashioned. It has been asserted, that the most lovely of all things are the Greek statues and the Greek tragedy; and ingenious, and perhaps somewhat fanciful persons, have imagined that they perceived a certain resemblance in the peculiar style of the sculptors and tragedians of Athens.

The sentiment of repose is strongly inculcated by the best productions of the Grecian chisel, and critics are sometimes dissatisfied with the small amount of action and the little apparent exertion; and they affirm that the expression is occasionally even that of listlessness. In inferior productions, on the contrary, we observe an excess of action, and a straining, that are painful to the spectator, especially if he regards them for a long time; we find the same sobriety, frugality, and even parsimony, in the other compositions of the ancients, especially in their writings, which must seem cold and languid to the admirers of the exaggerated expressions of modern authors.

In classical works, the more exalted the personage, the more calm and dignified are his emotions; but the hero of a modern drama or other work of the imagination often seems, by his violence and unnatural contortions, to be convulsed by the powerful action of a Galvanic battery, rather than impelled and agitated by mere human feelings; unless we may adopt a more obvious and simple solution of the difficulty, and suppose him to be a maniac. We presume to speak on this subject with great diffidence and distrust, but we must confess that the ancients have sometimes carried the sentiment of repose to an excess, especially in *bas reliefs*, in which the figures, although they are engaged in pursuits demanding the utmost energy, and of intense interest to all concerned, appear frequently to be more than half-asleep. It cannot be denied, however, that an excess of tranquillity is less displeasing than a display of unnecessary and outrageous violence.

The nakedness and full draperies of ancient times form a striking contrast with the close, strict, and scanty clothing of modern days, and show us symbolically the former copiousness and pristine candour, in opposition to the disingenuous concealments and narrow poverty of degenerate souls. Statues and other marbles and sculptures may be so easily, cheaply, and perfectly copied, by means of plaster-casts, that no considerable city ought to be without a public museum, containing a copy of all the best pieces of this kind in existence. If a few churlish persons should for a time refuse permission to take a cast, a drawing or some other imitation of the sculpture that

was wanting might occupy the place of the cast, and an inscription might inform the visitor where the original was to be found, and give the name of its unworthy possessor, who refused to the lovers of art the facilities which others had cheerfully granted. We possess many excellent antiques in bronze. If the colour be less agreeable than that of marble, the superior toughness of the material admits of greater spirit and freedom of execution; and of this advantage the ancient workmen knew how to avail themselves to the utmost, as any good collection of these remains will fully demonstrate, especially the many admirable specimens that are exhibited in the *Studii* at Naples.

The most remarkable, and perhaps the most inimitable, excellence of ancient art, is the perfection that was displayed in cutting gems, whether the figure be sunk beneath the plane surface of the stone, as in the *intaglio*, or projected above it, as in the *cameo*. If, on the one hand, gems are imperishable, and almost indestructible, on the other they are easily lost by reason of their small size. The prodigious number of engraved stones already known to the curious, and which is continually augmented by the discovery of new and beautiful specimens, proves that a vast amount of labour and of exquisite skill was formerly employed on these minute and delicate works. Rings, which were originally composed of coarse materials, and were used as seals, tokens, and for other purposes of necessity, in progress of time gradually grew into articles of immense luxury and cost. The taste for these ornaments had become universal in the civilized world in the time of Alexander the Great, who was fond of having his portrait cut on gems; and men were equally fond of wearing his image, not through a servile adulation, for the fashion or passion continued for several centuries after his death, but from a notion that it was lucky, which was indeed the chief motive in the choice of subjects for rings. In modern times we waste our gems by engraving upon them the ugliest device of a barbarous age—coat-armour; in like manner much valuable material and much precious labour were expended anciently, in the days of waning liberty, to preserve the worthless portrait of some dull sample of a Jove-descended king. The public acts of free states had sometimes been sealed with the likeness of an individual who had been a benefactor to the community, as a lasting and delicate compliment, that might flatter, but could not wound, the generous modesty of a disinterested patriot. The emperors of Rome, with that more than Aristophanic genius for burlesque and caricature for which they were remarkable, and of which the comic effect was the more striking and humorous, because the masters of the world were perfectly unconscious that they were heaping ridicule upon their own sacred heads, adopted the usage with many aggravations and additions for their own glory. The patriotic Tiberius extended the laws of treason—laws by which it was declared to be high treason to treat with disrespect the statues of the emperor—in order to protect from insult, by the last and highest penalties, his own image on a ring. We desire to confine our censure to the abuse of portraits. Many of the antique likenesses of individuals, who are remembered on account of their virtues or their talents, are highly interesting: there are several valuable collections of this kind in other places, but the Capitoline Museum at Rome is the grand repertory of ancient portraits. We read that in ancient times there were large collections of engraved gems, both glyphs and anaglyphs, as in our own days; and we have moreover innumerable books, containing representations of the most celebrated *Dactyliothecæ*, of very various degrees of merit, to enumerate which would be tedious. The amulets and astrological characters on rings have given occasion to the display of much curious learning. Superstition has long been familiar with the importance of rings: Apollonius of Tyana deemed them so essential to quackery, that he had seven—for each day of the week a different one, marked with the planet of the day. The scenic mask, whether tragic or comic, but especially the latter, was a favourite device: we have seen many gems that exhibit beautiful and surprising examples of that wonderful creation of the fancy. It affords one instance also of the many that might be cited to show that ancient forms are often preserved in a whimsical manner, and applied to purposes very remote from those for which they were originally designed. We have often observed an antique comic mask carved in stone on the end of a spout on our churches, and the exaggerated mouth from which jests not less grotesque than itself, but well seasoned with Attic salt, were used to issue, giving free vent to mere rain-water: so universal and indestructible is the influence of antiquity. As a class, coins are perhaps the least interesting of antiques; for, with few exceptions, they serve to illustrate nothing but the succession of a family or dynasty of kings. They have, however, long been favourite objects with collectors, partly on this account, and partly because persons who cannot attain to the comprehension of any other part of the study of antiquities, can at least understand the formation of an unbroken series, and that it is often difficult to complete it. We may concede also in favour of this branch of the science, that the Numismatists have sometimes rendered assistance to chronology, and have even cleared up certain points of geography, and therefore in subordinate departments have aided the historian.

Certain eminent artists and accomplished critics have given it as their decided opinion, that enough remains of the ancient painting to demonstrate that the ancients were as much superior to the moderns in this art, as they are admitted to have been in sculpture. It seems probable that the first efforts of design were mere shadows or outlines; of this early style the fictile vases afford examples. We have, however, many specimens of finished works in fresco, which are preserved at Rome and in Naples. Of the former, the Roman remains, some idea, although, it must be confessed, a very inadequate one, may be derived from the engravings in Turnbull's *Treatise on Ancient Painting*. Of the latter, the *Pitture di Ercolano* are more faithful and satisfactory representations. The style of the ancient painters, so far as our imperfect materials will permit us to judge, rather resembled that of Perugino and Raphael in grace, beauty, and sweetness, than the sublimity and graphic δεινοτης of the angelic and immortal Michael.

Michel più che mortal, Angiol divino.

Of the celebrated encaustic painting we know nothing, but that the ancients have left us some brief and vague descriptions, and the moderns have made some fruitless attempts to revive or re-discover it.

Of the Mosaic painting we have some very lovely vestiges, and some of them are as fresh and as fair as when they were first laid; with patient industry they may be imitated, either with stones, with morsels of glass, or with small tiles coloured and glazed. This kind of work is of bewitching beauty: the eyes of Homer had been so captivated with it, that he continued after his blindness to describe heaven by its pavement; at least if the critics will permit us to give this sense to the word δαπεδον.

We learn from the remains of ancient painting, that it was usual to adhere scrupulously to particular colours for the draperies of certain gods and heroes; and we may trace the same practice in the works of many of the Italian masters, who assign invariably the appropriated colours to

the clothing of saints and personages of note in Christian story.

In countries where fuel was scarce the process of burning bricks was expensive; unburnt bricks were therefore much used. In consequence of the greater heat of the sun they were hardened in southern climates more perfectly than the very limited portion of sunshine that northern regions enjoy could possibly effect; and we read that the desiccation was continued for several years before they were consigned to the builder. If the rain, which in the south at certain seasons falls in torrents, were warded off, wherever the air is generally dry such structures would last for a long period (the perpetual humidity of our atmosphere, even if we were able to prepare them properly, would speedily decompose them); but, even under the most favourable circumstances, a pile of unburnt bricks is a perishable structure, and many celebrated edifices have accordingly perished. More durable and more ornamental materials, however, have been fortunately very plentiful in those countries where invention and a pure taste in architecture were most prevalent; and some of the most celebrated of the productions of antiquity have resisted the gradual attacks of time, and the sudden violence of barbarians. In a few instances they are nearly entire; in many more, enough remains to enable us to restore the building to its original state, or to build another exactly similar to the former. Nor have architects been wanting in diligence in this respect; very accurate surveys, and exact and minute admeasurements and drawings, models and descriptions of every kind, have been executed by competent persons, to the great benefit of their art. We should be enabled to judge very correctly of the effect of the ancient temples and other edifices of celebrity, many of which have been admirably restored in small drawings and engravings by architects, if the restorations were painted in fresco on the walls of our public buildings in various points of view, and of the full size of the originals. Since Greece, and especially Athens, has been so carefully explored, and the results of much valuable labour made public, our taste in architecture has been greatly improved. The various members, at least, and the details of the buildings that have been lately erected in Great Britain, are more elegant than they were formerly. Unfortunately, however, we do not seem to possess an architect capable of combining the beautiful parts into one harmonious whole. It should appear, therefore, that a more profound and enlarged study of antiquity is required to make the artist in this line a master of general effect. A literary work may be faultless in its details, and yet it may be inefficient as a whole; it may be impossible to fix blame upon any single page or paragraph, yet the entire history of Greece, or of Rome, may be unworthy of the events which it undertakes to record. The narration, although the style be chaste and correct, may be lifeless, spiritless, and uninspiring. So is it in architecture; and such is the present state of that art in Great Britain. Our architects seem equally incapable of producing a whole, either in the Grecian or the Gothic style, although the parts may sometimes in themselves have merit. A silhouette, shade, or profile of the object in question, especially if it be taken in various points of view, will afford the most simple, ready, and satisfactory means of determining, and is the most certain and conclusive test whether the effect as a whole be good. If our latest erections be tried in this manner, the contours will invariably prove to be insipid and uninteresting, and often ill proportioned and ugly.

The Romans surpassed the rest of mankind less in the arts of government than in that remarkable art which Seneca aptly compares to the constitution of civil society, the building of arches and vaulted roofs of masonry. The astonishing and colossal relics of their mastery in this useful and difficult department of architecture have received much less attention than many works of very inferior beauty and utility. The most vulnerable part of a building is the wooden frame of the roof, which is always in danger of being destroyed by fire. It seems, however, to be unnecessary in the construction of edifices of some kinds to use wood at all. The tiles or other external covering might be supported, as they were in some of the ancient temples, by light arches of masonry, which, as the weight they would have to bear would be insignificant, might be built so slightly as not to oppress the parts beneath that sustain them. Many of the arches in the circus of Caracalla, near Rome, are composed of large earthen vessels walled together, instead of bricks or stones; and of this contrivance there are other examples at Rome. The superior lightness is manifest; the strength of an earthen vessel, and its power of resisting mere pressure, is considerable. That such structures were sufficiently solid, is demonstrated by their standing to this day. The expedient is worthy of imitation, and of more attention than it has hitherto received. The cupola of the church of San Vitale at Ravenna is the most remarkable specimen of this sort of building, being composed entirely of cylindrical earthen vessels, which are placed in a horizontal position, and are so arranged as to form one spiral coil, the end of the one vessel being always inserted into the mouth of the other, like the pipes that convey water through our streets. This very curious structure is exactly coeval with the body of the civil law, being of the age of the emperor Justinian; and it is said to be in equally good repair, and as likely to last for some ages longer, as the *Corpus Juris*. M. d'Agincourt has fully explained this simple but ingenious contrivance, and has expressed in a plate, more than it is possible to convey by verbal description alone, in his great work entitled *Histoire de l'Art par les Monumens depuis sa Décadence à 4me Siècle jusqu'à son Renouvellement à 16me.* Paris, 1823.

The same disposition of stones, and the same artifices, which would serve to support more securely the roof of a temple of masonry, would be equally effectual in diminishing the tendency of the roof to fall in a cavern or excavated temple; and we see, in fact, that they were actually employed in the latter case, and with results equally satisfactory. The ordinary configuration of the artificial roof of a temple is well adapted to lighten the natural roof of a cavern, especially if the peculiarities of formation be carried to a greater extent than we usually find in edifices. The part that would fall in first, and bring down the rest with it, is the middle, it being most distant from the supports: this is cut away and formed into hollow pannels, deepening in gradual succession. The Etruscan catacombs supply remarkable instances of all these contrivances. We even find the hole in the centre of the cupola, which is designed to lighten the living roof, where it is least able to hang in the air, and which also serves to admit the day. Of the two problems to support a natural and an artificial roof, the one is precisely the converse of the other; it being necessary in the former to hew away whatever portion of space would not be occupied by the structure in the latter. Certain architectural critics attribute, we know not how correctly, the undercrofts or crypts which are commonly found beneath cathedral churches, to the catacombs; of which, they assert, they are an imitation and memorial; because the catacombs were, it is said, the first places of worship used by the early Christians. It is certain that the catacombs at Rome serve as a crypt to the church of St Sebastian, and it is also certain that the sepulchral chambers of the Pagans,

which are far more ancient than the Christian worship, although they were never built under the floor of temples, closely resemble crypts.

The tombs of the ancients are very interesting to the archæologist, because, besides a multitude of pots and pans, and some vases of merit, they have furnished a countless host of lamps, that have formed the subject of many amusing volumes, and some excellent paintings in fresco, and other objects of considerable importance. The ancients sought to alleviate as much as possible, by calling up ideas of cheerfulness, grace, and beauty, the heavy burthen of death. The Greeks were eminently distinguished by the warmth and the strength of the domestic affections. Their tragedies present many lovely pictures of the vigorous and luxuriant growth of all the more tender charities, and every part of the history of their rites of sepulture brings fresh proof of the power and prevalence of the most amiable feelings among this ingenious and cultivated people. The creation of families, and the maintenance of them in the closest union and intimacy, is undoubtedly the most desirable object of public and private institutions; for it is from his family in childhood and in youth, in manhood and in old age, that man's happiness is mainly derived. We must be careful, however, not to mistake the means for the end, and we must always remember that laws, institutions, and principles, that were designed to advance an end, are only valuable so far as they serve the purpose for which they were designed. Men who do not steadily look to final causes are apt to gild and hang garlands on a scaffolding pole, and, in their insane worship of their wooden idol, to forget the marble palace, for the sake of which alone the unsightly pole was erected. The great success of the Greeks in the cultivation of these affections may be principally attributed to their extraordinary toleration and liberality; for, in other countries, where there is more prudish precision than mild and temperate forbearance, by drawing the silken bonds too tight, they are often broken. If those rules of decorum which are to be observed only with a certain moderation, and ought often to be considerably relaxed with a wise equity, are enforced by the arbiters of society with a rigid and literal severity, they will infallibly create heartlessness, hypocrisy, and disgust, and there will be but little domestic happiness or affection. Genius is in its nature eccentric; and if no allowances be made for its aberrations, men of talent will be converted into enemies,—and they are most formidable ones. If the treatment that may not be unsuitable to the humble and patient ass be attempted towards the generous steed, it will rouse a spirit of resistance and revenge not unworthy of the lion. Many writers have discoursed at great length of the ancient sepulchral rites. The folio of Mark Anthony Boldetti, entitled *Osservazioni sopra i Cimiterj de' Santi Martiri, ed antichi Cristiani di Roma*, contains a great body of curious information, and many valuable inscriptions; and the compilation is made palatable by a certain simplicity and amusing credulity. It is difficult to believe, if we reason from analogy, that were it possible to restore the ancient system of music, it would not richly repay the labour that might be bestowed on the task.

It is not from the contemplation of the remains of antiquity in the fine arts alone that we may hope to derive benefit; in many of the mechanical arts the ancients were decidedly our superiors; and by assiduous study of the specimens of various articles, and of the descriptions of certain processes, we may hope that ingenious practical men will learn to restore lost arts, and to amend and improve those which we possess. The ancient locks, for example, were of an admirable and very various construction. Bramah's justly celebrated inventions are merely, as is commonly known, an adoption of as many of the devices of the ancient locksmiths as modern artists are at present able to understand. In the manufacture of glass, the ancients were as much our superiors as in several other arts. This is demonstrated by the accuracy, variety, and delicacy of the forms into which they have moulded vessels of this substance. Among the other excellencies of this manufacture, we may mention the gems formed of paste in imitation of stones, to which we owe the preservation of some of the most beautiful antique engravings, the originals having been lost: many of these are of a large size. The manufacturers of porcelain have not hitherto been very successful in impressing their works with the stamp of genius and true taste; the Chinese origin is still manifest in the shapes of even the best pieces of crockery: herein let them pray the aid of the ancients. The construction of the antique chariots is perhaps not altogether unworthy of our attention, for even the smallest and lightest of our carriages appear to be unnecessarily large and heavy. Among the minor difficulties that were mastered by the skill of antiquity, was that of driving and managing many horses abreast. We see on a gem in the work of Count Caylus (*Recueil d'Antiquités*, tome i. Plate LX. fig. 4) a chariot with 20 horses yoked in this manner. Three horses abreast are often used on the Continent, and with a good effect. We have heard that an equestrian amateur tried the experiment in England successfully, but we do not remember to what extent. The Grecian breed of horses, it is believed, was much smaller than the English carriage-horses. If a London drayman, therefore, would be surprised to meet an Athenian team rapidly advancing in a single line, the Attic charioteer would scarcely be less astonished at the immense bulk of the animals that slowly march in a long file. This branch of the subject, however, would lead us too far from our original design.

It would be dangerous to enter upon the disputed ground of Etruscan art; for even the most experienced and confident critics confess that it is sometimes very difficult, if not impossible, to distinguish Etruscan monuments from those of the early ages of Greece. It is certain, however, that this ancient nation was much addicted to superstition and the fine arts. The lax erudition of Dempster,[1] the learning and critical skill of Lanzi,[2] and the labours of a myriad of antiquaries, and particularly of the estimable Gori,[3] are ready to conspire in instructing and perplexing the student.

Remains of Egyptian art.

Archæological critics are by no means agreed as to the degree of merit that is to be ascribed to the Egyptian works of art. Artists unanimously admit that the mechanical execution is very admirable; and travellers assert with one voice, that we cannot safely and correctly judge of their peculiar character or general effect from the ordinary engravings. We are required, moreover, in order to arrive at sound and solid conclusions on this difficult question, to distinguish most carefully between the original and pure Egyptian works, and the modern and spurious imitations that were manufactured when the rites of Isis were fashionable in Rome; and generally to be on our guard against whatever was executed whilst Egypt was under the sway of the Romans, and to esteem it as very inferior to the genuine productions of the country. A still further degree of caution may perhaps be necessary: the degradation of the old style probably was gradually pre-

[1] *De Etruria Regali*, 2 vols. fol.

[2] *Saggio di Lingua Etrusca*, 3 vols. 8vo.

[3] *Museum Etruscum*, 3 vols. fol.

Antiquities. pared, and advanced slowly during the period of more than three centuries, when Egypt was under the Grecian dominion of the Ptolemies, before it passed by conquest into the hands of the Romans. Plato indeed informs us, at the commencement of his second book *De Legibus*, that the Egyptian sculptors and painters were forbidden by law to change in any respect the forms of the statues and paintings, but were required to follow scrupulously the ancient models—and that there were in his days works in the temples of Egypt 10,000 years old; that they had not an old-fashioned antique appearance, but were precisely like the latest productions, and were neither more nor less beautiful. This testimony to the rigid adherence of their artists to patterns of such extraordinary antiquity may possibly add to our confidence in the genuineness of Egyptian antiquities in general.

In the midst of beauty we are often shocked by a certain ugliness; so, in the Egyptian statues, in their very ugliness there is, if we may use an apparent contradiction in terms, a certain beauty—a gravity, a dignity, a seriousness, a certain decorum: there is perhaps in the air and expression a display of moral beauties, while, save health and strength, all physical ones are wanting. Grotesque and whimsical as these figures are, they awaken a feeling of reverence; but the statues of the Hindoos, if we may judge from the representations of them which we see in Europe, are endowed with an unredeemed, unreclaimed, and unmixed ugliness, and inspire only disgust and contempt. The Egyptian statues possess one quality, which is esteemed no vulgar merit in works of art,—a perfect repose: it is striking at first sight, and the more attentively and the longer we contemplate them, the more profound does it appear. Men of good sense, good taste, and learning, who have been sufficiently fortunate to have had opportunities of judging of the Egyptian architecture, assert that the general effect is very wonderful, and that the feeling of repose is produced in an eminent degree by the prodigious proportions of their colossal edifices,—a sense of endless duration and of eternal rest. It is a striking thing to pass at once, by opening a door or raising a curtain, from the filth, noise, glare, and bustle of a hot and busy street, to the calm purity, cool shade, and quiet beauty of a richly adorned church. The transition must have been still more striking when the Egyptian temples stood, as did most of them, in crowded cities, to be suddenly translated from the tumult, and turbulence, and the storms of active life, to the deep, unbroken rest, the waveless harbour, of those who had long been dead. The magnitude, solidity, and ponderous weight of the objects have no doubt some share also in the effect which the contemplation of them produces on the mind. We feel that beauty is always alluring, and we feel also, as we before observed, that a certain kind of ugliness is sometimes respectable and imposing. But the Egyptian works of art are not invariably ugly; there is nothing in which determined admirers will not find beauty; but less suspicious witnesses, ordinary unprejudiced travellers, declare they have found statues that were actually beautiful, particularly the countenance of the famous Sphinx.

We have ventured to make these remarks on Egyptian art at the hazard perhaps of appearing dogmatical, for to express any opinion must have that appearance in the eyes of those who have none; and it may be also somewhat paradoxical, for such is the lot of all who venture to think for themselves, or even to adopt any received opinions, except the most popular.

The judgment of Strabo was not favourable to the Egyptian architecture. He seems to consider it a barbarous style, that has nothing graceful or picturesque, and that it displays only a vain waste of labour. His words are confined to some particular temple, which he criticises: they seem, however, to admit of a general application, and they express the opinion of many. Εστι δε τις πολυστολος οικος καθαπερ εν Μεμφει, βαρβαρικην εχων την κατασκευην· πλην γαρ του μεγαλων ειναι, και πολλων, και πολυστιχων, των στυλων, ουδεν εχει χαριεν, ουδε γραφικον, αλλα ματαιοποιιαν εμφαινει μαλλον. (Lib. xvii.)

"Immensa res est Ægyptiorum religio, seu cultus vetustatem spectemus, seu varietatem." The immensity of the subject will deter us from entering upon it. We may remark, however, in passing, that the worship of one favourite deity still subsists in that country; we mean of *Ælurus*, the god cat. So great is the fondness of the Mahometans for that animal, and so excessive their indulgence towards him, that they may be said still to worship him in Egypt. The lady cat was not less a favourite than her lord; she was equally adored, and her image was as frequently made. This matter is treated in the 8th chapter of the 6th book of the supplement to Montfaucon.

The Egyptians acquired some celebrity among other nations on account of their adoration of vegetables and pot-herbs. No other people, however pious, have made a pantheon of the kitchen-garden, unless we suppose that the Welsh, who are very prone to religion, have succeeded them in the worship of the onion, in its milder representative the leek; for the respect they show to that sacred plant seems to be greater than the importance of its divine presence in mutton broth, or even its fragrance to a Celtic nose, will warrant; and it seems, therefore, to partake somewhat of the nature of a religious observance.

An attentive consideration of the structure of the Greek and Latin languages is a labour that always insures its own reward; but this department of the study of antiquity must be reserved for another occasion. The assiduous reading of old books forms of course a most important part of the study of which we treat. We would not, however, determine the antiquity of a work merely by the number of ages since it was written. A book may have been published in remote times, and yet it may closely resemble a production of yesterday. If it affords examples of the ancient modes of thinking and acting, it is well worthy of the attention of the archæologist, who estimates it according to the antiquity of the sentiments, and not the date of the composition.

The early antiquities of Greece are unfolded by several of the best masters of language in the Greek tongue. Homer displays the heroic ages with a purity and fidelity which are not less remarkable than his other transcendent merits. His wonderful poems abound in every kind of archaisms, or may more truly be said to be entirely composed of them. When we read him, we learn to think as Achilles and Ulysses thought; we go back at once to the times when his specious miracles were wrought; we are contemporaries of Priam and Helen; and we become as well acquainted with the leaders of the Greeks as if we had passed a night with them in the Trojan horse. Herodotus is the beautiful Ionic bridge of nine arches, by which we pass from the heroic ages to the times of wonderful men—of Plato, Pericles, Demosthenes, and the other worthies who flourished at different periods of the Athenian republic, but are seen clustering together when viewed at the distance we now regard them.

Herodotus breathes the genuine spirit of antiquity. He was wisely ordained to effect the difficult and delicate transition from the mythic to the historical: he has performed his office with pre-eminent skill, and has passed the golden chain to his successors as he received it from the hands of him who took it up at its origin, the throne of the Olympian Jove. These two authors, and the other

depositaries of Grecian antiquities, are studied, not indeed so generally, so attentively, or so philosophically as we could wish; but nevertheless they attract a certain degree of respect and observation. We lament that the early antiquities of Rome, which are pregnant with interest and instruction, are not always sought to be derived from the best sources. Virgil is full of the sentiments and feelings of a Roman, and we cannot affirm that his epic is neglected; nor the history of Livy, who has eloquently, and briefly related the first fortunes of the eternal city; but we assert with regret, that the most valuable and faithful historian of that remarkable period is at present most unaccountably overlooked. We will venture to enlarge somewhat upon the nature of the work to which we allude, in the hope that a few details may be a relief to our readers after the very general observations we have alone been able to make on an extensive subject; and we shall be truly happy if we attract the public attention to, and succeed in any degree in rescuing from unmerited neglect, the Roman Antiquities of Dionysius of Halicarnassus. If we compare our English literature with that of other countries, we shall find it rich in many, and indeed in most respects. There are a few subjects, however, as to which our poverty is remarkable: it is perhaps the most remarkable as to translations from Greek and Latin authors. The French have many good ones, which are much read. In former times men of considerable eminence enriched the Italian language with several valuable and excellent translations; and more recently in Germany, writers of the greatest learning, and the highest reputation, have undertaken this important task, and they have succeeded admirably, having produced specimens of extraordinary merit, singular fidelity, and extensive popularity. With us, on the contrary, if we make a very few exceptions, translators have been persons of slender attainments and of very moderate diligence, who have executed their important office in a slovenly manner, and whose productions are hardly known by name, not only to ordinary readers, but even to persons of very extensive general knowledge and large acquaintance with books in the English language. The forcible expressions of Dryden concerning one of the early translators of Polybius, are in a great degree applicable to our best English interpreters: "Neither did that learned Italian, who had undertaken him, succeed very happily in that endeavour; for the perfect knowledge of the Greek language was not yet restored; and that translator was but as an one-eyed man amongst the nation of the blind—only suffered until a better could be found to do right to an author whose excellence required a more just interpreter than the ignorance of that age afforded."

This deficiency is to be regretted, not only on account of the great majority of readers (who are not, and cannot be acquainted with the learned languages, especially with the Greek), because they are not furnished with the means of studying in their own tongue the matter of many estimable authors; but it is to be deplored also on account of the proficients in the learned languages themselves, for of the great numbers who study them, few attain to a sufficient familiarity, and enjoy leisure enough to read in the original all the voluminous works that deserve to be perused, and to form a general idea of their contents. The classical student is commonly only able to master some short works as specimens of the rest, and some select passages from the larger works, and to obtain thereby a higher and nobler idea of the force and beauty of style, and of the powers of language and its perfections; and, by learning the grammar of other languages, to gain a notion of universal grammar, and to learn his native language grammatically; and therein he has his reward. But in order to make himself acquainted with the contents of many important works, he needs translations nearly as much as those who are entirely ignorant of the languages in which they are written.

It is singular that the same city produced the two great archæologists of former days: that Halicarnassus gave birth to the father of Grecian history, Herodotus, to whom we owe our knowledge of the antiquities of Greece; and to Dionysius, the author of the Roman Antiquities, to whom we are equally indebted for the principal part of the information that we possess respecting the earliest institutions, and the history of the first ages of Rome. Dionysius came to Rome in the reign of Augustus, at the conclusion of the civil wars. He resided for 22 years in the imperial city, and spent that long period in diligently collecting materials for his work, in studying the Latin language, in reading all the authors who had written concerning Roman affairs, and in constant personal intercourse and intimacy with the great men of the time. His history was comprehended in twenty books, and extended from the foundation of the city to the commencement of the first Punic war, from which epoch Polybius had related the Roman affairs with singular judgment and fidelity, in his inestimable work. Of the twenty books eleven only remain, which comprise little more than the first three centuries of the existence of Rome. The author manifests a profound acquaintance with the matters of which he treats. He fully illustrates the manners and customs of the ancient Romans, their laws, religion, and discipline in peace and war, explaining many antiquated expressions and names, and relating the origin of states and cities; and his knowledge of geography and chronology is remarkable, and gives an additional value to his work. He is not only more full than Livy, since he expands into eleven books a period of more than 300 years, which is condensed into three books by the Roman historian; but he is admitted also to be more exact and correct, and is universally acknowledged to be the most valuable of all the historians of Roman affairs.

The Greek writers are our best and most instructive guides in all that respects the Romans, because they wrote for Greeks, that is to say, for persons who were ignorant of the Roman manners and institutions; and they address themselves, as it were, *to us*. The Romans wrote in the Latin language, and their compositions were intended to be read by those who were already familiar with the subjects of which they treat. They allude therefore to domestic matters with extreme brevity; and their allusions are always obscure, and would commonly be unintelligible to us, but for the explanations with which we are supplied by the more copious Greeks, who being strangers themselves, write with a fulness which strangers can understand. Without the foreign authors, and especially without Dionysius of Halicarnassus, the knowledge of the moderns, if it were derived from Latin sources alone, would be very scanty and unsatisfactory. The most valuable Roman histories are those which are written in Greek. Except Plutarch's Lives, Greek writers concerning Roman affairs have been little read in England. The histories in Greek are all imperfect; they have discovered more or less, and some portions only remain. An old French translator of Appian expresses his high sense of their value in a quaint manner. In reference to this, he says that the Deity was so much offended at the bloodshed, oppression, and cruelties, through which the Roman empire was founded, that in order to deprive the Romans of a part of the glory which they sought by these misdeeds, and as an adequate punishment, he has not suffered any one of the histories which manifest their glory to reach us entire.

It would be easy to bring a host of testimonies to the great value of Dionysius. Among the ancients, Eusebius praises his remarkable accuracy; Cyril bears witness of his great fame; Photius celebrates his diligence, and the simplicity, sweetness, and beauty of his style; and Suidas his universal erudition. Since the restoration of letters, learned men have vied with each other in commending him. It is needless to repeat the encomiums of Paulus Manutius, Joseph Scaliger, Justus Lipsius, Sigonius, Petavius, Salmasius, Isaac Casaubon, Le Clerc, and Vossius, or even to enumerate the names of the great critics by whom he has been extolled, and of whom some, as Henry Stephens, prefer him on many accounts to his great rival Livy. One reason for his preference is philosophical, and worthy to be stated; he says that the history of Livy is military, and that of Dionysius civil. Dionysius is much read on the Continent by the French, Germans, and Dutch. He is the delight of the Italians, and has long been a favourite and popular author in Italy. Angelo Maio, in his courtly yet dignified dedication of a work, of which we will speak presently, to the present emperor of Austria, says that the emperor once told him he had often read the history of Dionysius with great interest: "Tum etiam addidisti magno tibi studio Halicarnasseum Dionysium jam inde ab annis virentibus lectitatum." Although a lively interest, and as it were a certain sympathy, is felt by the English in Roman history, he has not yet become familiar to us. An Englishman, Hudson, published at Oxford an excellent and splendid edition of the original Greek text; but it has found few readers in this country. The Greek poets are chiefly studied at our universities, and some portions of some of the Attic prose writers: the style of Dionysius is certainly difficult to those who are not acquainted with other authors. He is not read therefore in the ordinary course of education; and the studies of scholars who are so happy as to be able to keep up their knowledge of Greek are commonly directed by circumstances into a different channel. The Roman Antiquities have been translated into English some time since, by Edward Spelman. Although this is not by any means one of our worst translations, yet it is not such as ought to satisfy the lover of Roman history. It is not easy to assign a reason why the writer, from whom we derive the best and most detailed account of the institutions of Rome, should not be a general favourite in England; and why we take our information at second hand from those who have compiled histories of Rome by drawing largely upon him. Dionysius has been blamed for inserting fables; but, if it be a crime, he is less guilty in this respect than Livy; and it is not easy to say by what authority he could take upon himself to reject those portions of early history which, however incredible, were generally received in Rome; and, in the account of an extraordinary people, the history of their superstitions is not without its use. He was moreover a person of distinguished piety; and it is not a little curious to compare the religious feelings, notions, and practices, of those times with the superstitious observances of the over-zealous of our own days. He was well skilled also in the philosophy of the ancient world, and is rich in valuable and instructive reflections, which illustrate the state of opinion in the Augustan age; and his morality (and this is no ordinary merit in any writer, but especially in a historian) is generally of the highest order; and he powerfully and authoritatively inculcates, with all the powers of consistent integrity, and the authority of superior learning, the paramount importance of justice, whether public or private, and the great interests of virtue. A notion has prevailed in England, which appears to have originated in France, that he is not an agreeable writer. It is commonly asserted and believed that his style is flat and languid, and he is said to be a rhetorician. A conceited French Jesuit, named René Rapin, set the fashion in France, which has prevailed there, and in England also to a certain extent, to undervalue Dionysius as a writer. His petulant editor Reiske has adopted it, and Mr Gibbon, a man infinitely superior to Rapin or Reiske, repeats the censure, but with considerable mitigation. Mr Gibbon derived his tastes and his principles chiefly from French writers; and the style which he has adopted in his own immortal work shows that he had no taste for a full and copious narrative, but was of opinion that a history, like the response of an oracle, should be conveyed in brief, obscure, enigmatical allusions. A modern French writer, Schoell, strong in the confidence of ignorance, ventures to say, "son style, formé d'après celui de Polybe, son modele, n'est pas toujours d'une pureté classique." Dionysius, in common with all judicious critics, duly appreciated the civil prudence and military knowledge, the fidelity, accuracy, and good sense, and all the estimable qualities of Polybius; but so far was he from taking his style as a model, that he places him among those writers whose style is the most faulty, and whose works, on that account, it is hardly possible to read to the end. (*De Structura Orationis*, sect. 4.) As to the complaint that he was a rhetorician, it cannot be denied that we are indebted to him for the best rhetorical treatises in the Greek tongue. It is certain that he was a rhetorician, but that he was not a *mere* rhetorician is equally certain. The cultivation of language was carried to so great an extent in the time of Dionysius, that the most eminent men produced works on that subject; and Julius Cæsar himself, as is well known, was the author of a grammatical or rhetorical treatise, *De Analogia*, which was esteemed. That Cæsar was not a *mere* rhetorician, was a misfortune to Rome and to the world.

The error of undervaluing a writer of the Augustan age because he was skilled in rhetoric, arises from confounding different times. Subsequently there were no other pursuits than grammar, rhetoric, and the like; learned men were *mere* rhetoricians, and nothing more, and were not good even in that narrow line, to which a hopeless despotism had confined their energies.

Dionysius has also been censured for having introduced too many orations into his history; but he abounds less in speeches than many other historians who are highly esteemed. He had studied oratory with great attention, and had composed criticisms on the principal orators of Greece, which are still extant, and are highly and deservedly prized. It was natural, therefore, that he should endeavour to put in practice the rules of composition which he had laid down in such a masterly manner; and many of his harangues have been warmly praised by very competent judges, for great magnificence of language, a rich vein of good sense, a remarkable elegance and address in the selection and arrangement of arguments, and indeed for all the resources of eloquence. If the speeches are sometimes long, they are never superfluous; they are, in truth, merely a mode of relating events, and differ from ordinary narrative in manner only. Occurrences, instead of being told in the common course of history, for the sake of variety, and to produce a lively and dramatic effect, are detailed in an oration: they are shown not only as effects, but as causes—as causes in actual operation, and as producing the consequences that flowed from them; and are thus more deeply impressed on the mind of the reader. No one can pretend that the person to whom the speech is attributed delivered it in the precise words used by the historian. That he did make a speech at Rome, where it was usual to do so on

many occasions, is highly probable: it may in many cases be related by contemporary writers as a fact, and as a part of the history of the transaction. In order that he may fully understand the subject, and, of course, the motives of the principal actors, a careful writer, who is about to compose a history, studies the whole matter with the utmost diligence. It is true that he may have failed altogether; for men fail in all undertakings: but if he has been successful in discovering the motives of the speaker, it is likely that the speech is in substance the same as that which was actually delivered;—that it was the same in words we cannot suppose;—indeed, some of the best histories are in a language different from that which was spoken by the persons whose acts or fortunes are related.

Since sceptical history has been fashionable, too low a value has been put upon such writers as Dionysius. The French invented sceptical, or, as they term it, philosophical history; and they conducted their inquiries, although somewhat arbitrarily, yet with a certain tact, with ingenuity and good taste. The Germans adopted it, as they are wont, without acknowledgement; and using greater erudition and elaboration, and every variety of uncommon sense, outraged and caricatured it, and rendered investigation so ridiculous, that the only way to avoid being laughed at seems now to be to believe every thing we read. It was once asked, What is truth? and the question did not receive an answer: in like manner we may ask, What is probability? If every reader may reject whatever appears improbable to himself, the page of history will soon become as naked and bare as the head of the middle-aged bigamist, who, as the fable tells us, married an old and a young wife.

If Livy and Dionysius, who lived so much nearer to the times of which they write, were unable, by reason of the great antiquity, to discover the truth, how is it possible for a professor on the banks of the Rhine, the Seine, or the Thames, nearly 2000 years after, to find what has been so much longer hidden? Livy honestly and modestly gives up the hopeless attempt in despair, and says, "Cura non deesset, si qua ad verum via inquirentem ferret: nunc famæ rerum standum est, ubi certam derogat vetustas fidem." It would be a pious and profitable work, to the studious reader at least, if not to the patriotic translator, to make a new translation of the Roman Antiquities, a book which has been justly called a "grave, learned, accurate, and golden volume," the production of an author who has been said with equal justice "to have written better about the Romans than they did about themselves." To translate it as it deserves, and to the entire satisfaction of the translator, would demand great natural and acquired powers, and a very long period of uninterrupted leisure; but to induce some learned man to attempt to render it into English, in some respects at least according to the idea of accurate interpretation which we form in the mind, and to give it in such a shape as would be acceptable and agreeable to the English reader, and might become popular, is all that we can venture to hope in our most sanguine moments.

Angelo Maio, the librarian of the Vatican library at Rome, published, a few years since, from a manuscript in the Ambrosian library at Milan, an abstract or epitome of the last nine books, which are lost. Photius informs us that Dionysius made such an epitome of the entire work himself; and the learned editor is of opinion that the manuscript which he discovered contains a copy of the author's own abridgement. Some critics have doubted whether it be the work of which Photius speaks; but it has not been doubted that the fragments are portions of the lost books of Dionysius, although they question whether the selection was made by himself.

As they contain many very interesting passages, and relate to that period of the republic of which the existing memorials are the most scanty, and have never been published in English, it would be desirable to add a translation of the epitome, and thus to complete, as far as is possible, the history of Rome from its foundation to the beginning of the first Punic war. A benevolent translator, who sought to serve his country by the diffusion of useful knowledge, would give, in a preface of moderate dimensions, an account of the author, and of his other compositions, and of the different editions and translations of this work, so far as they are of importance; of its general design and nature; and such observations respecting the Romans, as would facilitate the understanding of their ancient history. He would add notes to illustrate obscure passages, to point out ambiguities, and wherever the interpretation admits of variety; together with references to authors who confirm, contradict, or differ from Dionysius; comprehending also additional explanations of the laws, rites, customs, and institutions, wherever these are to be obtained, and the author seems to need them; and such information respecting the earlier writers who are cited in the Roman Antiquities, and their works, as can be gleaned from trustworthy sources. In writing notes, to be plain and intelligible ought to be the constant aim of an annotator. He ought especially to keep in view the grand object, utility; he should religiously avoid the discussion of trifles, however tempting they may be on account of their difficulty, or as furnishing opportunities for the display of fruitless ingenuity, a vain ostentation of learning, and the empty parade of citation; he should seek to gather the fruits of erudition, wherever they are within his reach, and should permit the leaves of pedantry to remain untouched, and rustle in the winds.

We have ventured thus to enlarge upon the merits of Dionysius, because we are persuaded, that a careful perusal of the historical works of this neglected author would greatly assist the student in forming correct and clear notions of the more ancient, fundamental, and original institutions, which properly belong to the study of antiquities.

We may consider the civil law as forming a most valuable ingredient in the general education of a scholar and a citizen on three accounts. 1*st*, It is useful to the legislator, to teach him, by the efficacious discipline of good examples, in what manner to make laws, and how to clothe them in language at once brief, comprehensive, and perspicuous; 2*dly*, to the magistrate and the lawyer, to instruct them, by a display of the long-continued practice of the most able and accomplished men, in the administration and sound and consistent interpretation of laws; and, 3*dly*, this science is peculiarly interesting to the archæologist, as being rich in precious illustrations of many of his favourite pursuits. And we would gladly adduce some instances of its value in the last point of view; but we are afraid to commit ourselves to this vast ocean of erudition, and must be satisfied with having merely indicated it as an inexhaustible mine of antiquarian wealth.

The beauty, variety, and richness of the precious remains of antiquity (that we may resume the general consideration of the subject) are sometimes even oppressive; and they overpower the mind, when it contemplates attentively the great theme of ancient excellence. We endeavour naturally to discover the cause of this excellence, but we are not competent fully to solve the problem;—we are perhaps able to make some approaches towards its solution. The inhabitants of Athens, that we may go at once to the centre and fountain-head, were not less distinguished for and characterized by an intense love of and passion for the beautiful, and by the universality of good taste, than by an extreme tolerance. There was nothing extravagant in the productions of the imagination in

that free city; but how much, and what monstrous extravagance, do we constantly find, combined with great genius and invention, in the compositions of men who lived under despotism? If good taste was universal in Athens, it was very general in Florence in the best days of that state, when its inhabitants enjoyed a great but inferior degree of civilization. Under the ecclesiastical government of modern Rome there has always been, on account of the weakness of the rulers, much licentiousness, and a considerable portion of practical freedom, together with a correct taste in the fine arts. We may remark, by the way, that the papal government, like that of Athens, for many ages contrived to produce the greatest effects with the most scanty means; and the history of the holy see proves that its occupier, like the people of Athens, seldom failed to promote learned and able men, and freely to acknowledge on all occasions the pre-eminence of learning. Clement VIII., on nominating the celebrated Jesuit and archbishop of Capua, Bellarmin, declared publicly, "We choose him cardinal because the church of God does not possess his equal in learning." The history of the successors of St Peter, if such they were, is replete with examples of the same wise policy. To convince ourselves that good taste prevails exactly in proportion as works of art are addressed to the people at large, and designed for public inspection, it is only necessary to look around us. At Rome, where they are freely thrown open to all, the works of the government are in a pure taste; in Paris they are less public, and less correct: if there be any country in the west of Europe where the monarch lives in complete seclusion among his household ministers and women, as in the East, we may safely conclude, that whatever works are executed at the public expense, but are not intended to be submitted to the public view, are conceived in the worst and most vulgar and degraded taste, and that they are worthy of a Byzantine emperor or an oriental prince. The history of the declining empire, and the specimens of art of the first ages of Christianity that still remain, demonstrate that the fine arts were corrupted and lost when they ceased to be employed for public purposes, and ministered only to the private and selfish gratification of emperors and wealthy individuals, who consumed the property of the people in monstrous and guilty luxury.

If the greatness of the ancients be a wonderful and inexplicable thing, it is not less wonderful how this greatness was destroyed and annihilated. The more we consider the ancient world, the more astonishing does this total destruction appear. Many ingenious men have attempted to assign the true causes, but no one has fully succeeded hitherto in explaining the extraordinary catastrophe. If we might venture to hazard a conjecture on the obscure subject, we should be inclined to attribute it principally to intolerance. The steady growth of this baneful disposition gradually destroyed every thing: by continually dividing and subdividing, the great masses were reduced to smaller, these again to fragments, and finally to mere dust, which was blown away by the wind. The greatest men are always the least orthodox, because they think most; and men who think for themselves cannot fall into the common tracks, at least for a long line of road. The ignorant and dull, on the contrary, who do not exercise their understandings, but the memory only, learn easily to repeat the watchwords of some narrow sect, which, as they are few in number, are not easily forgotten; and having no originality to lead them astray, they outbid their superiors, and produce more of the only coin that is current, and have nothing to fear but the more tenacious memories of their inferiors in ability. Wherever orthodoxy of any kind whatever is acknowledged as the test and criterion of success and merit, the mark of contraband is set upon talent, and a premium, a right of pre-emption, and a secure monopoly, are given to the base and vile. It is to this fatal cause we would attribute the utter extinction of the ancient glory.

In studying the remains of antiquity, we ought to entertain with modest confidence the encouraging hope, that the day will arrive when the ancient excellence will be equalled, or even surpassed; and we ought especially to cherish and foster the generous desire of imitating the objects which we reverently admire. It has even been said that we ought to be prejudiced in favour of these works, to be predisposed to admire them, to view them with the eye of faith; that it is very easy to persuade ourselves we see nothing remarkable in them, but very difficult to appreciate them fully, and to understand thoroughly their value. We conceive, however, that it is not easy to show that any advantage would be gained by substituting faith as a guide for the understanding in the place of reason, or that our judgment ought not to be directed by certain rules, which will admit of being stated, examined, and compared among themselves, and with the principles of things. To place the standard of excellence high, and to set a high value upon excellence, is favourable to a generous emulation, and conduces to ultimate success. It is unnecessary to caution the reader against a blind admiration of antiquity. The general indifference of an age, in which he who knows any thing is apt to imagine that he knows it *a priori*, through the uninstructed force of his own mind, and which is sufficiently disposed to consider itself wiser than any that preceded it, to the knowledge of past times, will insure him against an excess in this respect. It is not without much hesitation that the maxim, *peritiores vetustas facit*, will now be admitted.

We will readily concede, however, that the respect for the wisdom of our ancestors may easily be carried too far, especially if that wisdom was manifested in barbarous ages; and a reverence for authority that leads us entirely to distrust our own powers would disable us, and render us incapable of exertion or improvement. It would be difficult to decide whether we should err more grossly in believing nothing that we read, or in yielding implicit faith to the assertions of every author.

The taste of the present age is somewhat inclined to favour historical scepticism. A specimen of easy credulity will not be the less amusing on account of its old-fashioned air. We transcribe the following passage from *L'Antiquité Expliquée* of Montfaucon, tome i. p. 44:—"Jupiter le Pluvieux, Pluvius, appellé par les Grecs Ζευς ομβριος, et par Lucien ὑετιος, étoit honoré par les Atheniens, qui lui avoient dressé un autel sur le Mont Hymette. Nous le donnons d'une manière bien extraordinaire, tel qu'il est représenté dans la colonne Antonine. C'est un vieillard à longue barbe, qui a des aîles, et qui tient les deux bras étendus, et la main droite un peu élevée: l'eau sort à grands flots de ses bras et de sa barbe. Les soldats Romains de l'armée de Marc Aurele, que la secheresse et la soif avoit reduits à une extrême necessité, reçoivent cette eau dans le creux de leurs boucliers. Les Romains, plongés encore dans le paganisme, attribuèrent ce prodige à leur Jupiter Pluvieux. Mais ce furent, dit avec plus de raison Baronius dans ses Annales, les soldats Chrétiens qui obtinrent cette pluie qui sauva l'armée." This passage is conceived in the true spirit in which marvellous relations ought to be read, if we desire to have history stuffed full of wonders. The miracle itself ought to be accepted as an undoubted fact, without scruple or hesitation; and the only difference of opinion among historians ought to be as to the authority or influence to which it is justly to be attributed. There would have

been many more specimens of ancient art in existence at present, if this amicable and pacific credulity had prevailed in all ages, and to the full extent to which it might, with advantage to society, be carried; if the tolerant rule of conduct had been to repair the temple, to spare and hospitably to entertain the statue, to preserve the sculpture or painting, but to apply different names to them, and to use them for various purposes, according to the fancy and fashion of the age. The figure of Jupiter Pluvius of Montfaucon is really very curious: he is flowing with water, which is descending in torrents from every part, his left wing only excepted. We find the same figure of this deity in the work of the learned Roman John Baptist Casalius, *De Urbis ac Romani olim Imperii Splendore* (p. 49), represented in a rude but spirited sketch, with the attendant circumstances: for the particulars of the story we are referred to Baronius, *sub anno* 176. The crosses *fleuris* on the shields of the soldiers in the latter engraving are, we presume, an addition of the engraver, or perhaps of Pope Sixtus V., who repaired the column of Antoninus.

The captivating fables of the ancient mythology are useful as a part of liberal education; and it is good for children to read them in order to form the imagination. It is a vulgar and a pernicious error to believe that this faculty may be neglected with impunity. Persons in whom, through a narrow and vicious institution, the cultivation of the invention has been neglected, have rarely reached great eminence; and if by diligently exercising the reasoning powers they have for a short time attained to some small reputation, they have scarcely ever been able to sustain, much less to increase it. Whenever they have attempted to exert their unformed fancy, and to extend thereby their fame, they have commonly made themselves ridiculous, by failing in inventing something probable, and falling into the monstrous: their fictions moreover want the attractiveness which a practised taste can alone give to the creations of the imagination. The most acute logical powers, and the most profound knowledge of the rules of rhetoric and criticism, are unavailing without the higher faculty of invention, which discovers arguments and apposite illustrations, and finds the proper media of conviction and persuasion. Truth is undoubtedly the end of knowledge, but it commonly happens that the end can only be attained through the means of fiction. Whatever departments of knowledge are suited to the wants and capacities of children, are also adapted for the lower orders, who in many respects are always children of a taller stature. The common people can understand and feel the advantage of amusements, of cultivating the feelings and the taste for the beautiful, but they are unable to learn the abstract sciences, and it would be of no service to endeavour to teach them. As men begin to take an interest in general matters, they cease to be curious concerning particulars. To get rid, therefore, of the minute and troublesome curiosity which is the infallible characteristic of the ignorant and vulgar, and is strong exactly in proportion to the want of mental cultivation, every encouragement ought to be afforded to honourable recreations and liberal studies. The equality of the political rights of every citizen has been perhaps more distinctly acknowledged in modern times; and if it be clearly ascertained and firmly secured, much, no doubt, is done to assure the wellbeing of civil society. Many other institutions besides those which are required for this purpose are nevertheless essential, or at least highly conducive, to the happiness of mankind. Men have other wants besides security, liberty, and equality; and for some of them better provision was made in certain states of antiquity than in the present days the people have thought proper to demand, or their rulers to grant. For the amusement of the lower classes, although diversions may be more requisite in some climates than in others, they are of more importance in all than is commonly supposed: for the cultivation of their tastes, and for many parts of their education, much labour and money, much thought and talent, were employed in Greece and in Rome. Refinement and civility were accordingly universally diffused, and the general happiness of society was greatly augmented; for the people were rendered capable of new and exquisite pleasures, and these pleasures were liberally supplied to them. In countries where no wish to gratify and indulge the lower ranks is manifested by their superiors, but rather a desire to thwart their diversions, and a sullen pride in interfering with the few pleasures they are capable of creating for themselves, the unhappy result is, that a general rudeness and disgusting brutality become the common characteristics of the labouring classes.

To be fully impressed with the great truth, that amusement is as necessary to man as bread, it is requisite to consult the golden pages of antiquity: it is unfortunately not very easy to state in a few words where the student can find the best expositors of those pages. A good work is needed to guide us in the vast labyrinth of past ages; a work that would avoid on the one hand a vague and desultory manner of treating the subject, and on the other those minute details which are interesting only to professed artists and archæologists; a work that would reject the husks and retain the nutritive parts of erudition. Writers have hitherto in general reversed this rule, and given abundant cause for the complaint, "L'antique n'a servi à la plupart des savans qu'à étaler une immense érudition, et il a été regardé comme peu fait pour nourrir l'esprit." No profane literature is more tiresome than the commentaries on ancient works of art by ordinary antiquaries; they are dull and heavy with heaped up citations. There is much scope for felicitous innovation in such a work as we desire. Of many of the remains of ancient art only conjectural explanations have been given, which in some cases are tolerably satisfactory; in many others it is impossible to acquiesce in them: so is it also in truth with many passages of the classics,—the ignorant reader can alone rest content with the interpretation they ordinarily receive.

It is sometimes a difficult matter to detect restorations; and the art of the critic, who would decide as to the genuineness of antiques, is not unfrequently perplexed. By not distinguishing the modern restorations from the original composition, many ludicrous mistakes have been committed: it would be the duty, therefore, of the accomplished guide to render us assistance in this delicate department, and to lay down for our direction sound canons of criticism. Impediments have been thrown in the way of the study of antiquity. This legitimate pursuit has been superseded and brought into discredit by the spurious imitation of the antiquary, by an insane fondness for our own barbarous antiquities, for heraldic trumpery, and similar trifling. We recall the remembrance of days when every thing was worse than at present, that we may learn to shun, not to imitate. They are happy who have had free access in their youth to good copies and representations of the antiques, and thrice happy who have been able at any period of life to study many of the originals.

The sedulous vulgar, seeking to degrade what they are unable to understand, speak slightingly of looking at pictures, as if it were one of the many forms of idleness; but the studious read not in books alone, and it must be a good modern book which contains as much instruction as a tolerable engraving of an antique. The ancient works of art have been engraved with a suitable spirit

and effect by the Italians almost alone of nations. Whenever the French artists draw or engrave from the antique, they pretend to imitate the severity and simplicity of the ancients, and outrage even their own natural hardness, and, with very few exceptions, cease to be only painful, and become intolerable. It is to be regretted that this acute and enterprising nation cannot enter into the feeling of the antique; for they have, with the most laudable zeal and exemplary diligence, studied the science of antiquity. The numerous plates in the *Encyclopédie Méthodique* on the subject of antiquities are ugly, and the explanations and disquisitions are confused and senseless. *L'Antiquité expliquée et représentée en Figures,—Antiquitas explanatione et schematibus illustrata,*—is an immense body of information, written in French and in Latin, adorned with numberless plates. The learned and laborious compiler, Dom Montfaucon, as we before observed, is credulous and injudicious; and so much has been discovered since his time, that his work is very incomplete. It is however deservedly popular; scarcely any other work is consulted in England, except by a few. The great size of this compilation, which consists, including the supplement, of ten ponderous volumes in folio, places it out of the reach of all but the wealthy; and so is it unhappily with many other works that are important and indeed essential to the study of antiquities. They are to be found, it is true, in every well-stocked library; but private collections are of course accessible to a few only: and although there are many excellent and ample libraries, where the books are the property of the public, students are, with very few exceptions, shut out. Count Caylus, a true practical philosopher, complains somewhere of the jealousy of the king of Spain with regard to antiques. In this matter as well as in others, and elsewhere as well as in Spain, subjects have hitherto been too complaisant to their rulers, and the best governments have not been sufficiently liberal in encouraging learning. We will refer the student to one valuable guide, the admirable Winckelmann, recommending him at the same time to read his works, like all German books, with extreme caution; not because the author has any design to deceive others, but because he is indued with a remarkable aptitude to be himself deceived.

If we have succeeded in any degree in leading the future inquiries of our readers to the conclusion, that the spirit and tendency of the institutions of antiquity were generally favourable to the advancement and improvement of the human mind, we shall have laid a solid ground for the veneration which we are ourselves disposed to claim for them. On account of their intrinsic merit in other respects, but especially on account of their popular character, and their design to promote human happiness, we venture with some confidence to adopt and repeat the well-known advice of Pliny: "Reverere gloriam veterem, et hanc ipsam senectutem, quæ in homine venerabilis, in urbibus sacra est: sit apud te honor antiquitatis, sit ingentibus factis, sit fabulis quoque." (U.)

ANTISABBATARIANS, a modern religious sect, who oppose the observance of the Christian sabbath. The great principle of the Antisabbatarians is, that the Jewish sabbath was only of ceremonial, not moral obligation, and consequently is abolished by the coming of Christ.

ANTISCII, people who live on different sides of the equator, whose shadows at noon are projected opposite ways. Thus the people of the north are Antiscii to those of the south; the one projecting their shadows at noon towards the north pole, and the other towards the south pole.

ANTISCORBUTICS, medicines good in scorbutic cases.

ANTISEPTICS, from αντι, and σηπτος, *putrid*, of σηπω, *I putrefy*, an appellation given to such substances as resist putrefaction. We have some curious experiments in relation to antiseptic substances by Dr Pringle, who has ascertained their several virtues. Thus, in order to settle the antiseptic virtue of salts, he compared it with that of common sea-salt, which being one of the weakest, he supposes equal to unity, and expresses the proportional strength of the rest by the higher numbers, as in the following table.

Salts, their antiseptic virtue.

Sea salt	1	Saline mixture	3
Sal gemmæ	1+	Nitre	4+
Tartar vitriolated	2	Salt of hartshorn	4+
Spiritus Mindereri	2	Salt of wormwood	4+
Tartarus solubilis	2	*Borax*	12+
Sal diureticus	2+	Salt of amber	20+
Crude *sal ammoniac*	3	Alum	30+

In this table the proportions are marked in integral numbers; only to some there is added the sign +, to show that those salts are possessed of a stronger antiseptic virtue than the number in the table expresses, by some fractions; unless in the three last, where the same sign imports that the salt may be stronger by some units.

ANTISPASMODICS are medicines proper for the cure of spasms and convulsions. Opium, balsam of Peru, and the essential oils of many vegetables, are the principal in this class of medicines.

ANTISTASIS, in *Oratory*, a defence of an action from the consideration that, had it been omitted, worse would have ensued. This is called by Latin writers *comparativum argumentum;* such, *e. g.* would be the general's defence who had made an inglorious capitulation, that, without it, the whole army must have perished.

ANTISTHENES, a Greek philosopher, and founder of the Cynics. He was born at Athens, and passed the former part of his life as a soldier. Having afterwards been an attendant at the lectures of Socrates, he was principally charmed with those exhortations of that great philosopher which persuaded to frugality, to temperance, and to moderation: these Antisthenes was resolved to practise by carrying every precept to its utmost extent. Permitting, therefore, his beard to grow, he went about the streets in a thread-bare coat, scarcely to be distinguished from a common beggar. He prided himself upon the most rigid virtue, and thought himself obliged to attack the vicious wherever he found them. This gave him some reputation in the city; but it may be supposed that, in a place so very luxurious as Athens, he had more enemies than disciples. His philosophy consisted rather in action than in speculation: it was therefore his constant maxim, that to be virtuous was to be happy, and that all virtue consisted in action; that the wise man should live for himself, contented in all situations, and happy alone in the consciousness of his own virtue. He acknowledged nothing to be good but what was honourable, and asserted that virtue might be acquired by practice. Diogenes Laertius tells us there were 10 volumes of his works; and he has given us many of his apophthegms.

ANTISTOCHEON, in *Grammar*, the using of one letter instead of another; as *olli* for *illi*.

ANTISTROPHE, in *Grammar*, a figure by which two things mutually depending on each other are reciprocally converted; as, *the servant of the master, the master of the servant.*

ANTISTROPHE, among lyric poets, that part of a song and dance, in use among the ancients, which was perform-

ed before the altar, in returning from west to east; in opposition to strophe.

ANTITACTÆ, in *Ecclesiastical History*, a sect of Gnostics, who held that God was good and just, but that a creature had created evil; and consequently that it is our duty to oppose this author of evil, in order to avenge God of his adversary.

ANTITHESIS, in *Rhetoric*, a contrast or opposition of words or sentiments. Such is that of Cicero, in the second Catilinarian: "On one side stands modesty, on the other impudence; on one fidelity, on the other deceit; here piety, there sacrilege; here continency, there lust."

ANTITRINITARIANS, those who deny the Trinity, and teach that there are not three persons in the Godhead. Thus the Samosatenians, who do not believe the distinction of persons in God; the Arians, who deny the divinity of the Word; and the Macedonians, who deny that of the Holy Spirit, are all properly Antitrinitarians. Among the moderns, Antitrinitarians are particularly understood of Socinians, called also Unitarians.

The *Bibliotheca Antitrinitariorum*, or *Antitrinitarian Library*, is a posthumous work of Christopher Sandius, an eminent Antitrinitarian, in which he gives a list, digested in order of time, of all the Socinian or modern Antitrinitarian authors, with a brief account of their lives, and a catalogue of their works.

ANTITYPE, a Greek word, properly signifying a type or figure corresponding to some other type. The word antitype occurs twice in the New Testament, viz. in the Epistle to the Hebrews, ix. 24, and in St Peter, 1 Ep. iii. 21, where its genuine import has been much controverted. The former says that "Christ is not entered into the holy places made with hands, which are, αντιτυπα, the figures or antitypes of the true—now to appear in the presence of God for us." Now τυπος signifies the pattern by which another thing is made; and as Moses was obliged to make the tabernacle, and all things in it, according to the pattern shown him in the mount, the tabernacle so formed was the antitype of what was shown to Moses: any thing, therefore, formed according to a model or pattern is an antitype.

Antitype, among the ancient Greek fathers, and in the Greek liturgy, is also applied to the symbols of bread and wine in the sacrament. Hence it has been argued by many Protestants, that the Greeks do not really believe the doctrine of transubstantiation, because they call the bread and wine *antitypes*, αντιτυπα, q. d. *figures*, *similitudes*, and this even after the consecration.

ANTIVARI, or Bar, a strongly fortified town and harbour in the Gulf of Venice, in the Turkish pachalic of Iscander or Scuttari. It is a frontier town, the seat of a Catholic bishop, and contains 3500 inhabitants, who are owners of several vessels, which are hired for the coasting trade of the Adriatic Sea. It is in lat. 42. 25. N. and long. 18. 54. E.

ANTLIA, an ancient machine, supposed to be the same with our pump. Hence the phrase *in antliam condemnari*, according to the critics, denotes a kind of punishment whereby criminals were condemned to drain ponds, ditches, or the like.

ANTŒCI, those inhabitants of the earth who live under the same meridian, and at the same distance from the equator; the one toward the north, and the other toward the south. Hence they have the same longitude; and their latitude is also the same, but of a different denomination: they are in the same semicircle of the meridian, but in opposite parallels: they have precisely the same hours of the day and night, but opposite seasons; and the night of the one is always equal to the day of the other.

ANTOINE, a town of France, in Dauphiny, in the diocese of Vienne, with a celebrated abbey. It is seated among the mountains, 13 miles east of Lyons. Long. 5. 20. E. Lat. 45. 43. N. Antoine || Antonides.

ANTONIA, Saint, a town of France, in the department of Lot and Garonne, and in the diocese of Rhodes, whose fortifications are demolished. It is seated on the river Aveiron. Long. 0. 55. E. Lat. 44. 10. N.

ANTONIAN Waters, medicinal waters of Germany, very pleasant to the taste, and esteemed good in many chronic and hypochondriac cases.

ANTONIANO, Silvio, a man of great learning, who raised himself from a low condition by his merit, was born at Rome in the year 1540. When he was but ten years old he could make verses upon any subject proposed to him. The duke of Ferrara, coming to Rome to congratulate Marcellus II. upon his being raised to the pontificate, was so charmed with the genius of Antoniano, that he carried him to Ferrara, where he provided able masters to instruct him in all the sciences. From thence he was sent for by Pius IV., who made him professor of the belles lettres in the college at Rome. Antoniano filled this place with so much reputation, that, on the day when he began to explain the oration *pro Marco Marcello*, he had a vast crowd of auditors, and among these no less than 25 cardinals. He was afterwards chosen rector of the college; and after the death of Pius IV., being seized with a spirit of devotion, he joined himself to Philip Neri, and accepted the office of secretary to the sacred college, offered him by Pius V., which he executed for 25 years with the reputation of an honest and able man. He refused a bishopric which Gregory XIV. would have given him; but he accepted the office of secretary to the Briefs, offered him by Clement VIII., who made him his chamberlain, and afterwards a cardinal. Antoniano injured his health by too great fatigue; for he spent whole nights in writing letters; which brought on a sickness, of which he died in the 63d year of his age.

ANTONIDES Vander Goes, John, an eminent Dutch poet, was born at Goes in Zealand on the 3d of April 1647. His parents were anabaptists, people of good character, but of low circumstances. They went to live at Amsterdam when Antonides was about four years old; and in the ninth year of his age he began his studies, under the direction of Hadrian Junius and James Cocceius. Antonides took great pleasure in reading the Latin poets, and carefully compared them with Grotius, Heinsius, &c. By this means he acquired a taste for poetry, and enriched his mind with noble ideas. He first attempted to translate some pieces of Horace and Ovid; and, having formed his taste on these excellent models, he at length undertook one of the most difficult tasks in poetry, to write a tragedy. This was entitled *Trazil, or the Invasion of China*. Antonides, however, was so modest as not to permit it to be published. Vondel, who was then engaged in a dramatic piece, which was taken also from some event that happened in China, read Antonides's tragedy, and was so well pleased with it that he declared, if the author would not print it, he would take some passages out of it, and make use of them in his own tragedy. He accordingly did so; and it was reckoned much to the honour of Antonides to have written what might be adopted by such a poet as Vondel. Upon the conclusion of the peace between Great Britain and Holland, in the year 1674, Antonides wrote a poem entitled *Bellona aan band*, i. e. "Bellona chained," consisting of several hundred verses. He next wrote an ingenious heroic poem, which he entitled *The River Y* (the river on which Amsterdam is built).

Antonides's parents had bred him up an apothecary;

Antoninus. but his remarkable genius for poetry soon gained him the esteem and friendship of several persons of distinction, and particularly of Mr Buisero, one of the lords of the admiralty at Amsterdam, and a great lover of poetry, who sent him at his expense to pursue his studies at Leyden, where he remained till he took his degree of doctor of physic, and then his patron gave him a place in the admi. alty. In 1678 Antonides married Susanna Bermans, who had also a talent for poetry. His marriage was celebrated by several poets, particularly by Peter Francius, professor of eloquence, who composed some Latin verses on the occasion. After marriage he did not much indulge his poetic genius; and within a few years he fell into a consumption, of which he died on the 18th September 1684, being then but thirty-seven years and a few months old. His works have been printed several times, having been collected by Father Antony Tansz. A complete edition was printed by Nicholas Ten Hoom, at Amsterdam, in the year 1714, in 4to, under the direction of David Van Hoogstraaten, one of the masters of the Latin school of that city, who added to it also the life of the poet.

ANTONINUS Pius, a celebrated Roman emperor, was born A. D. 86, at Lanuvium in Italy. His family had long maintained the honour of the house of Nismes in Gaul, from whence they had descended. Both his father and grandfather had held the office of consul. Arius Antoninus, his maternal grandfather, by his amiable disposition and love of literature had acquired an eminent character, and was very intimate with Pliny the younger. Under him the young Titus, after his father's death, completed his education. His character, on arriving at the age of maturity, manifested itself in the most promising manner. To an improved understanding, a virtuous heart, a mild and dignified character, and a noble eloquence, he joined a happy physiognomy. Simple in his taste, and guided by temperance in all his actions and sentiments, he was entirely free from all affectation and pomposity.

In the year 120, among the many public honours which his birth and connections gave him a claim to, he was elevated to the high post of consul, and was afterwards appointed by Adrian to be one of the four consulars between whom the supreme power of Italy was divided. Becoming in his turn proconsul of Asia, he acquitted himself with such reputation that he even excelled his grandfather Arius, who had formerly enjoyed that high trust. Returning from Asia, he was not only received into the favour, but likewise the confidence and council of Adrian, and was always disposed to act with lenity. He married Annia Faustina, the daughter of Annius Verus, whose character was far from being untaxed with reproach; but his lenient disposition induced him to avoid public scandal, and he behaved towards his aged father-in-law with the most becoming respect. Two sons and two daughters were the fruits of this marriage. The sons died when they were young, and the eldest daughter, who was married to Lamia Sylvanus, died when Titus proceeded towards his Asiatic government. Faustina, the youngest, married Marcus Aurelius, who was afterwards emperor.

After the death of Verus, Adrian resolving to adopt Antoninus, he was induced to accept of the succession to so important a charge as the Roman empire, although with a considerable degree of reluctance, and was accordingly nominated by Adrian in February 25, A. D. 138, in the presence of the council of the chief senators; and he at the same time created him his colleague in performing the proconsular and tribunitial duties. Extending his plans of adoption still farther, Adrian caused Antoninus to adopt the son of Verus, then seven years of age, and Marcus Annius, afterwards named Aurelius, then seventeen years of age, a relation of Adrian's, and nephew to his own wife. The dutiful and merited attention which Antoninus bestowed on Adrian during the last months of his illness gives a very high idea of his character. On July 10, A. D. 138, he succeeded to the empire amidst the universal acclamations of the senate and people, who anticipated in his well-tried virtues that happiness which a good and wise sovereign is able to bestow upon his subjects.

The Roman world enjoyed such tranquillity under his reign that it affords few materials for history; yet it is to be regretted that Capitolinus is the only historian from whom any direct information can be received concerning this peaceful period, and he is none of the most perspicuous. It however appears that the usual honours and titles, together with the addition of the surname of Pius, which both his conduct and zeal in defending and honouring the memory of his predecessor united to suggest, were willingly conferred upon him by the senate. In the beginning of his reign there were several conspiracies formed against him; but this only afforded him an instance of signalizing his clemency, which he did in the most striking manner. Although he was unable to prevent justice from taking its due course against the ringleaders, he prohibited the prosecution of their accomplices, and took the son of Attilius, one of the principal conspirators, under his protection. Various commotions were raised in several parts of the empire; but by the vigilance of his lieutenants these were easily quelled. The incursions of the Brigantes in Britain were restrained, and a new wall which was built to the north of that of Adrian, from the mouth of the Esk to that of Tweed, and which was called the *Wall of Antoninus*, was fixed as the boundary of the Roman province in Britain. The reign of Antoninus, upon the whole, was singularly peaceful, and realized a saying of Scipio, that "he preferred saving the life of one citizen, to destroying a thousand enemies."

Jurisprudence was to this emperor, as it was to his predecessor, an interesting subject for improvement; and several decrees which he issued display his commendable spirit of equity. The natural consequence of this equity was, that Antoninus acquired a reputation and fame which no military achievements could have conferred; and his friendship was courted by the neighbouring princes.

There is scarcely a blot to be found to tarnish his character; and frugality, modesty, and harmless amusement continued to employ his private hours. In the management of his complicated business he was exact to such a degree, that it was even ridiculed by some; but he found the daily advantage of this accuracy. The growing virtue of Marcus Aurelius soon drew his attention after he ascended the throne, and having given him his daughter in marriage, he declared him Cæsar. Nor was he mistaken in his choice; for Aurelius acted with the utmost fidelity and affection amid all the honours that he continued to confer upon him. Enjoying this large share of domestic bliss, in the 75th year of his life he was seized with a fever, at his favourite country-seat of Lori. Convinced of his approaching fate, he convened the principal officers of the state, and confirmed his election of Aurelius, and gave him the imperial ensigns. A delirium ensued, in an interval of which he gave the watchword *Æquanimitas*, and calmly resigned his breath in the 23d year of his reign. His ashes were consigned to the tomb of Adrian, and divine honours paid to his memory. He was universally regretted, and succeeding emperors bore his name as a badge of honour. The senate and his successor erected a sculptured pillar to his memory, which is still shown to strangers as one of the chief ornaments of Rome.

ANTONINUS PHILOSOPHUS, *Marcus Aurelius*, a very eminent Roman emperor, born at Rome on the 26th of April,

<antonius.> in the 121st year of the Christian era. He was called by several names till he was admitted into the Aurelian family, when he took that of Marcus Aurelius Antoninus. Adrian, upon the death of Cejonius Commodus, turned his eyes upon Marcus Aurelius; but, as he was not then 18 years of age, and consequently too young for so important a station, he fixed upon Antoninus Pius, whom he adopted, upon condition that he should likewise adopt Marcus Aurelius. The year after this adoption, Adrian appointed him questor, though he had not yet attained the age prescribed by the law. After the death of Adrian, Aurelius married Faustina, the daughter of Antoninus Pius, by whom he had several children. In the year 139 he was invested with new honours by the emperor Pius, in which he behaved in such a manner as endeared him to that prince and the whole people.

Upon the death of Pius, which happened in the year 161, he was obliged by the senate to take upon him the government, in the management of which he took Lucius Verus as his colleague. Dion Cassius says that he was induced to do this on account of his ill state of health, and that he might have leisure to pursue his studies; Lucius being of a strong, vigorous constitution, and consequently more fit for the fatigues of war. The same day he took upon him the name of Antoninus, which he gave likewise to Verus his colleague, and betrothed his daughter Lucilla to him. The two emperors went afterwards to the camp, where, after having performed the funeral rites of Pius, they pronounced each of them a panegyric to his memory. They discharged the government in a very amicable manner. It is said that soon after Antoninus had performed the apotheosis of Pius, petitions were presented to him by the pagan priests, philosophers, and governors of provinces, in order to excite him to persecute the Christians, which he rejected with indignation, and interposed his authority for their protection, by writing a letter to the common assembly of Asia, then held at Ephesus. The happiness which the empire began to enjoy under these two emperors was interrupted, in the year 162, by a dreadful inundation of the Tiber, which destroyed a vast number of cattle, and occasioned a famine at Rome. This calamity was followed by the Parthian war; and at the same time the Catti ravaged Germany and Rhætia. Lucius Verus went in person to oppose the Parthians; and Antoninus remained at Rome, where his presence was necessary.

During this war with the Parthians, about the year 163 or 164, Antoninus sent his daughter Lucilla to Verus, she having been betrothed to him, and attended her as far as Brundusium. He intended to conduct her to Syria; but it having been insinuated by some persons that his design of going into the East was to claim the honour of having finished the Parthian war, he returned to Rome. The Romans having gained a victory over the Parthians, who were obliged to abandon Mesopotamia, the two emperors triumphed over them at Rome in the year 166, and were honoured with the title of *Fathers of their country*. This year was fatal, on account of a terrible pestilence which spread itself over the whole world, and a famine under which Rome laboured. It was likewise in this year that the Marcomanni, and many other people of Germany, took up arms against the Romans; but the two emperors, having marched in person against them, obliged the Germans to sue for peace. The war, however, was renewed the year following, and the two emperors marched again in person; but Lucius Verus was seized with an apoplectic fit, and died at Altinum. The Romans were now defeated with great slaughter; and the emperor, not choosing to burden his subjects with new taxes, exposed to sale the furniture of the palace, the gold and silver plate belonging to the crown, and his wife's rich garments embroidered with gold, and a curious collection of pearls, which Adrian had purchased during his long progress through the provinces of the empire, and was called *Adrian's cabinet*.

In the year 170 Antoninus made vast preparations against the Germans, and carried on the war with great vigour. During this war, in 174, a very extraordinary event is said to have happened, which, according to Dion Cassius, was as follows: Antoninus's army being blocked up by the Quadi in a very disadvantageous place, where there was no possibility of procuring water, and being worn out with fatigue and wounds, oppressed with heat and thirst, and incapable of retiring or engaging the enemy, in an instant the sky was covered with clouds, and there fell a vast quantity of rain. The Roman army were about to quench their thirst when the enemy came upon them with such fury, that they must certainly have been defeated, had it not been for a shower of hail, accompanied with a storm of thunder and lightning, which fell upon the enemy without the least annoyance to the Romans, who by this means gained the victory.[1] In 175 Antoninus made a treaty with several nations of Germany. Soon after, Avidius Cassius, governor of Syria, revolted from the emperor. This insurrection, however, was put an end to by the death of Cassius, who was killed by a centurion named Anthony. Antoninus behaved with great lenity towards those who had been engaged in Cassius's party: he would not put to death, nor imprison, nor even sit in judgment himself upon any of the senators engaged in this revolt; but he referred them to the senate, fixing a day for their appearance, as if it had been only a civil affair. He wrote also to the senate, desiring them to act with indulgence rather than severity; nor to shed the blood of any senator or person of quality, or of any other person whatever; but to allow this honour to his reign, that, even under the misfortune of a rebellion, none had lost their lives except in the first heat of the tumult. In 176 Antoninus visited Syria and Egypt. The kings of those countries, and ambassadors also from Parthia, came to visit him. He staid several days at Smyrna; and, after settling the affairs of the East, went to Athens, on which city he conferred several honours, and appointed public professors there. From thence he returned to Rome with his son Commodus, whom he chose consul for the year following, though he was then but 16 years of age, having obtained a dispensation for that purpose. On the 27th of September in the same year he gave him the title of *Imperator;* and on the 23d of December he entered Rome in triumph with Commodus, on account of the victories gained over the Germans. Dion Cassius tells us that he remitted all the debts which were due to

[1] The Pagans, as well as Christians, according to Mr Tillemont (art. xvi. p. 621), have acknowledged the truth of this prodigy, but have greatly differed as to the cause of such a miraculous event, the former ascribing it, some to one magician and some to another. In Antoninus's pillar the glory is ascribed to Jupiter the god of rain and thunder. But the Christians affirmed that God granted this favour at the prayer of the Christian soldiers in the Roman army, who are said to have composed the twelfth or Melitene legion; and, as a mark of distinction, we are told that they received the title of the *Thundering Legion* from Antoninus. (Euseb. *Eccles. Hist.* lib. v. cap. 5.) Mr Moyle, in the letters published in the second volume of his works, has endeavoured to explode this story of the Thundering Legion, which occasioned Mr Whiston to publish an answer in 1726, entitled, *Of the Thundering Legion; or, Of the Miraculous Deliverance of Marcus Antoninus and his Army upon the Prayers of the Christians.*

Antoninus's Wall.

himself and the public treasury during 46 years, and burnt the writings relating to these debts. In the year 179 he left Rome with his son Commodus, in order to go against the Marcomanni and other barbarous nations; and in the year following he gained a considerable victory over them, and would in all probability have entirely subdued them, had he not been seized with an illness, which carried him off on the 17th of March 180, in the 59th year of his age, and 19th of his reign. The whole empire regretted the loss of so valuable a prince, and almost every person had a statue of him. His book of *Meditations* has been much admired. It is the most precious work that has come down to us from the Stoical school. The Oxford edition of 1704, and that of London, published in 1707, are both esteemed. An English translation by Drs Moor and Hutcheson was published at Glasgow in 2 vols. 12mo, in 1749.

ANTONINUS'S WALL, the name of the third rampart or defence that had been built or repaired by the Romans against the incursions of the North Britons. It is called by the people in the neighbourhood *Graham's Dike*, from the notion that one Graham, or Grimus, first made a breach in it after the retreat of the Romans out of Britain. The first barrier erected by the Romans was the chain of forts made by Agricola from the frith of Forth to that of Clyde, in the year 81, to protect his conquest from the inroads of the Caledonians. The second was the vallum or dike thrown up by Adrian in the year 121. It terminated on the western side of the kingdom at *Axelodunum* or *Brugh*, on the Solway sands, and was supposed to have reached no farther than *Pons Elii* or *Newcastle* on the eastern; but from an inscription lately discovered, it appears to have extended as far as the wall of Severus. This rampart of Adrian's was situated much farther south than Agricola's chain; the country to the north having been either, according to some authors, recovered by the native Britons after the departure of Agricola, or, according to others, voluntarily slighted by Adrian. However, this work of Adrian's did not long continue to be the extreme boundary of the Roman territories to the north in Britain; for Antoninus Pius, the adopted son and immediate successor of Adrian, having, by his lieutenant Lollius Urbicus, recovered the country once conquered by Agricola, commanded another rampart to be erected between the friths of Forth and Clyde, in the track where Agricola had formerly built his chain of forts. The great number of inscriptions which have been found in or near the ruins of this wall or rampart, to the honour of Antoninus Pius, leave us no room to doubt its having been built by his direction and command. If the fragment of a Roman pillar with an inscription, now in the college library of Edinburgh, belonged to this work, as is generally supposed, it fixes the date of its execution to the third consulship of Antoninus, which was A. D. 140, only twenty years after that of Adrian, of which this seems to have been an imitation. This wall or rampart, as some imagine, reached from Caer-ridden on the frith of Forth to Old Kirkpatrick on the Clyde; or, as others think, from Kinniel on the east to Dunglass on the west. These different suppositions hardly make a mile of difference in the length of this work, which, from several actual mensurations, appears to have been 37 English or 40 Roman miles. Capitolinus, in his life of Antoninus Pius, directly affirms that the wall which that emperor built in Britain was of turf. This in the main is unquestionably true, though it is evident (from the vestiges of it still remaining, which not very many years ago were dug up and examined for near a mile together) that the foundation was of stone. Mr Camden also tells us that the principal rampart was faced with square stone, to prevent the earth from falling into the ditch. The chief parts of this work were as follows: 1. A broad and deep ditch, whose dimensions cannot now be discovered with certainty and exactness, though Mr Pont says it was 12 feet wide. 2. The principal wall or rampart was about 12 feet thick at the foundation, but its original height cannot now be determined. This wall was situated on the south brink of the ditch. 3. A military way on the south side of the principal wall, well paved, and raised a little above the level of the ground. This work, as well as that of Adrian, was defended by garrisons placed in forts and stations along the line of it. The number of these forts or stations, whose vestiges were visible in Mr Pont's time, was 18, situated at about the distance of two miles from each other. In the intervals between the forts there were turrets or watch-towers; but the number of these, and their distance from each other, cannot now be discovered.

It is not a little surprising, that though it is now more than 1600 years since this work was finished, and more than 1300 since it was slighted, we can yet discover, from authentic monuments which are still remaining, by what particular bodies of Roman troops almost every part of it was executed. This discovery is made from inscriptions upon stones, which were originally built into the face of the wall, and have been found in or near its ruins. From these inscriptions it appears in general, that this great work was executed by the second legion, the vexillations of the sixth legion and of the twentieth legion, and one cohort of auxiliaries. Some of these inscriptions have suffered greatly by the injuries of time and other accidents; so that we cannot discover from them with absolute certainty how many paces of this work were executed by each of these bodies of troops. The sum of the certain and probable information contained in these inscriptions, as it is collected by Mr Horsley, stands thus:

	Paces.
The second legion built	11603
The vexillation of the sixth legion	7411
The vexillation of the twentieth legion	7801
All certain	26815
The vexillation of the twentieth legion, the monument certain, and the number probable	3411
The same vexillation on a plain monument, no number visible, supposed	3500
The sixth legion, a monument, but no number, supposed	3000
Cohors prima Cugernorum	3000
Total	39726

or 39 miles 726 paces, nearly the whole length of the wall. It would be both useful and agreeable to know how long these troops were employed in the execution of this great work. But of this we have no information. Neither do we know what particular bodies of troops were in garrison in the several forts and stations along the line of this wall, because these garrisons were withdrawn before the *Notitia Imperii* was written.

Though we cannot discover exactly how many years this wall of the emperor Antoninus continued to be the boundary of the Roman territories in Britain, yet we know with certainty that it was not very long. For we are told by an author of undoubted credit (Dion Cassius, lib. lxxii.), that, in the reign of Commodus, A. D. 180, "he had wars with several foreign nations, but none so dangerous as that of Britain; for the people of the island, having passed the wall which divided them from the Romans, attacked them, and cut them to pieces."

ANTONIO, NICHOLAS, knight of the order of St

James, and canon of Seville, was born at Seville in 1617, being the son of a gentleman whom King Philip IV. made president of the admiralty established in that city in 1626. After having gone through a course of philosophy and divinity in his own country, he went to study law at Salamanca, where he closely attended the lectures of Francisco Ramos del Manzano, afterwards counsellor to the king and preceptor to Charles II. Upon his return to Seville, after he had finished his law studies at Salamanca, he shut himself up in the royal monastery of Benedictines, where he employed himself several years in writing his *Bibliotheca Hispanica*, having the use of the books of Bennet de la Sana, abbot of that monastery, and dean of the faculty of divinity at Salamanca. In the year 1659 he was sent to Rome by King Philip IV. in the character of agent general from the prince: he had also particular commissions from the inquisition of Spain, the viceroys of Naples and Sicily, and the governor of Milan, to negotiate their affairs at Rome. The cardinal of Arragon procured him, from Pope Alexander VII., a canonry in the church of Seville, the income whereof he employed in charity and the purchasing of books: he had above 30,000 volumes in his library. By this help, joined to continual labour and indefatigable application, he was at last enabled to finish his *Bibliotheca Hispanica*, in four volumes folio, two of which he published at Rome in the year 1672. The work consists of two parts; the one containing the Spanish writers who flourished before the 15th century, and the other those since the end of that century. After the publication of these two volumes, he was recalled to Madrid by King Charles II. He left nothing at his death, which took place in 1684, but his vast library; and his two brothers and nephews being unable to publish the remaining volumes of his *Bibliotheca*, sent them to Cardinal d'Aguisne, who paid the expence of the impression, and committed the superintendence of it to M. Martin, his librarian, who added notes in the name of the cardinal. These two volumes were published in 1696. Improved editions of both these works, by F. P. Bayer, were published at Madrid in 4 vols. folio, in 1783–8. A work by Antonio was published for the first time at Valencia in 1742, entitled *Censura de Historias Fabulas, obra postuma*, folio.

Antonio, *St*, one of the Cape de Verd Islands, about 40 miles in length and 20 in breadth. It is separated from St Vincent by a clear navigable channel two leagues in breadth. On the north coast there is a good road for shipping, with a supply of fresh water. The island stretches from north-east to south-west, and is filled with mountains, one of which is of so extraordinary a height as to be compared with the Peak of Teneriffe. Its top is constantly covered with snow, and, notwithstanding the clearness of the sky, generally hid in clouds. The island produces a variety of fruits, among which are oranges, lemons, melons, and some sugar-canes. The potatoes and melons are particularly excellent. Long. 25. W. Lat. 17. N.

ANTONIUS, Marcus, a famous Roman orator. While he filled the office of pretor, Sicily fell to his lot, and he cleared the seas of the pirates which infested that coast. He was made consul with A. Posthumius Albinus, in the year of Rome 653, when he opposed the turbulent designs of Sextus Titus, tribune of the people, with great resolution and success. Some time after he was made governor of Cilicia, in quality of proconsul, where he performed so many great exploits that he obtained the honour of a triumph. We cannot omit observing, that in order to improve his great talent for eloquence, he became a scholar to the greatest men at Rhodes and Athens, in his way to Cilicia, and when on his return to Rome. Soon after he was appointed censor, which office he discharged with great reputation, having carried his cause before the people, against Marcus Duronius, who had preferred an accusation of bribery against him, in revenge for Antonius's having erased his name out of the list of senators, which this wise censor had done because Duronius, when tribune of the people, had abrogated a law which restrained immoderate expense in feasts. He was one of the greatest orators ever known at Rome; and it was owing to him, according to the testimony of Cicero, that Rome might boast herself a rival even to Greece itself in the art of eloquence. He never would publish any of his pleadings, that he might not as he said, be proved to say in one cause what might be contrary to what he should advance in another. He was unfortunately killed during those bloody confusions raised at Rome by Marius and Cinna. He was discovered in the place where he had hid himself, and soldiers were sent to dispatch him; but his manner of addressing them had such an effect, that none but he who commanded them, and had not heard his discourse, had the cruelty to kill him. His head was exposed before the rostra, a place which he had adorned with his triumphal spoils. This happened 90 years before the Christian era.

Antonius, *Marcus*, the triumvir, was grandson to the former. When the civil war broke out, he took Cæsar's part, and was made a tribune of the people, in which office he did Cæsar great service. Cæsar, having made himself master of Rome, gave Antonius the government of Italy. At the battle of Pharsalia Cæsar confided so much in him, that he gave him the command of the left wing of his army, while he himself led the right. After Cæsar was made dictator he made Antonius general of the horse, though he had never been pretor; in which command he exerted his power with the utmost violence. He was made consul when Cæsar enjoyed that honour for the fifth time, the last year of that usurper's life. On Cæsar's death he harangued the populace with great art, and raised their fury against his murderers, flattering himself that he should easily get into the place which Cæsar had filled; but his haughty behaviour made him lose all the advantages his affected concern for Cæsar had gained him. His ill treatment of Octavius, and quarrel with him, produced another civil war, which ended in an accommodation between him, Octavius, and Lepidus, fatal to the peace of Rome. They agreed to share the supreme power among them; and many of the most illustrious Romans were sacrificed by proscription to cement this bloody league, which is known by the name of the *Second Triumvirate*. But the triumvirs were too ambitious, and hated one another too much, to be long united. Antonius went into Asia to raise money for his soldiers, and during his absence Fulvia, his wife, quarrelled with Octavius. When Antonius was in Asia, indulging himself in all manner of luxury, the famous Cleopatra inspired him with the most violent passion. Hearing of the quarrel between Fulvia and Octavius, and finding Octavius was become publicly his enemy, Antonius entered into a confederacy with Sextus Pompeius, who was still master of Sicily. He then went into Italy, in order to fight Octavius; but Fulvia, who had been the author and promoter of this war, dying, Octavius and Antonius came to an agreement. One of the conditions of this new peace was, that they should together attack Pompey, though the former had lately made an alliance with him. Antonius then married Octavia, sister of Octavius, as a pledge of their renewed friendship, but returned soon after to his beloved Cleopatra, and again lived with her in Alexandria. Octavius took hold of this pretence to inveigh against him, and begin the war again. At last they engaged in a sea-fight at Actium, in which Octavius gained a com-

Antonomasia || Antrim.

plete victory, which was followed by the death both of Antonius and Cleopatra. The infatuated Antonius fell upon his own sword; and Cleopatra stung herself to death with an asp, as was supposed, to avoid gracing the victor's triumph at Rome.

ANTONOMASIA, a form of speech, in which, for a proper name, is put the name of some dignity, office, profession, science or trade; or when a proper name is put in the room of an appellative. Thus a king is called his *majesty*; a nobleman, his *lordship*. We say the *philosopher* instead of Aristotle, and the *orator* for Cicero. Thus a man is called by the name of his country, a *German*, an *Italian*; and a grave man is called a *Cato*, and a wise man a *Solomon*.

ANTOSIANDRIANS, a sect of rigid Lutherans, who oppose the doctrine of Osiander relating to justification. These are otherwise denominated *Osiandromastiges*. The Antosiandrians deny that man is made just with that justice wherewith God himself is just; that is, they assert that he is not made essentially, but only imputatively, just; or, that he is not really made just, but only pronounced so.

ANTRIM, a maritime county of Ireland, in the province of Ulster, situate in the northern extremity of the island. It presents a considerable line of coast to the Northern Ocean and to the Irish Channel. By the former it is bounded on the north, and by the latter on the east. Carrickfergus Bay, or Belfast Lough, and the river Lagan, on the south-east, divide it from the county of Down, as far to the south as Spencer's Bridge. To the south-west it has the same county, which, running to a point, meets Loughneagh at Shanport. The winding shores of Loughneagh and Loughbeg form its boundaries on the west, as far as the point where it meets the river Bann; whence this river taking a northern course, inclining west, separates the counties of Antrim and Derry, until it touches the liberties of Coleraine (about 3000 acres), which are on the Antrim side of that river.

This county lies between 54° 26′ and 55°12′ north latitude. Its greatest length, from Bengove Head north to Spencer's Bridge south, is 41 Irish miles; and its greatest breadth, from the Gobbins east to Toome west, is about 24 miles; comprising, according to the latest authorities, 420,999 Irish acres.

Divisions.

In 1584–5 the county was divided into eight baronies, viz. Dunluce, Glenarm, Toome, Antrim, Belfast, Massereene, Carey, and Kilconway. Of late years all except the two last have been subdivided into half-baronies, called Upper and Lower. There are also smaller divisions, as parishes, granges, manors, constablewicks, townlands or quarterlands. The number of parishes is 72, the townlands amount to 1543. As far as the original names of the latter have been discovered, they are purely Celtic, and expressive of the qualities of the land, or of some other local circumstances. This subdivision is said to have taken place in the 13th century. Several of the granges are extra-parochial, and some of them do not pay tithes.

The county returns four members to the imperial parliament, viz. two for the shire, and one for each of the towns of Belfast and Lisburn, both of which are close boroughs. Carrickfergus, though within the lower half-barony of Belfast, yet is a county corporate, distinct from the county of Antrim. It is a free borough, and returns one member to parliament. In Carrickfergus are held the assizes, elections, and sessions twice every year, for the county of Antrim. The other chief towns are, Ballymena, Ballymony, Antrim, and Larne: sessions are held in the first three, and also in Belfast.

The bishopric of Connor comprehends the county of Antrim and liberties of Coleraine, except the parish of Aghalee, in the barony of Massereene, which is in the diocese of Dromore, and the townland of Ballyscullion-beg, on the Antrim side of the river Bann, attached to that of Derry.

The interior of the county on the eastern side is mountainous, nearly destitute of plantations, and abounding in bogs, many of which, from their situation, appear irreclaimable. This character also in some measure applies to the northern side; and it is computed that at least 119,136 acres are incapable of improvement. The baronies of Belfast, Antrim, Massereene, and Toome, are the most level and fruitful. A stupendous assemblage of basaltic columns, the Giant's Causeway, which is described under its own title, is seen on the maritime confines of Antrim; as also Fairhead, and other lofty capes and promontories. These are composed of thousands of prismatic pillars of various dimensions, ranged in successive strata, and so closely connected in some places that a cavity formed in the surface holds water. The principal mountains are, Knocklead, near Ballycastle; Aura, Trostram, Slemish; and Devis, near Belfast.

Besides basalt, there are found limestone, gypsum, coals, surturbrand or fossil wood, freestone, and marble. The fossil wood, or wood-coal, in most places, as at Ballintoy and Killymorris, is covered with columns of basalt. In burning it emits a disagreeable smell, resembling that of rotten wood. Notwithstanding the compressed state in which it is found, the bark and knots are quite distinct, and the rings denoting the annual growth of the wood may be counted. In some instances the roots of the trees may be traced. Their heads all lie to the east, and seem as if laid down by a storm. Of the three coal mines which are wrought in Ulster, there are two in Antrim; the one at Ballycastle, the other at Killymorris. The greater quantity of coal raised at Ballycastle is exported; at Killymorris little is raised, except in wet seasons when peat is scarce.

The rivers of this county are numerous, but in general small. The most considerable are, the Lower Bann, which discharges the waters of Loughneagh into the sea near Coleraine; the Lagan, which falls into the Lough of Belfast; and the Maine, which rises near Ballymony, and disembogues itself into Loughneagh near Randlestown. The other rivers are the Bush, Revel, Braid, Kells-water, Six-mile-water, Crumlin, and Glencavy, none of which is navigable. Near Ballycastle and Rasharkin are chalybeate springs; and there is a salt spring near Carrickfergus. Loughneagh, belonging more properly to the county of Armagh, will be described under that article. It may be proper, however, to notice in this place, that, of the two islands in this expanse of water, Ram Island, from its contiguity to Antrim, is considered as belonging to that county. It contains about seven acres, and is the property of Lord O'Neill, who has erected on it a beautiful cottage.

Rathlin Island lies off the northern coast of the county, opposite to the town of Ballycastle, from whose quay its nearest point is distant five miles. This island is about five miles in length, and, at a mean, upwards of three quarters of a mile in breadth, divided into 25 quarterlands, and containing 1996 acres, about one fourth of which is arable. Barley is almost the only grain sown, and, with kelp, furnishes their chief exports. In 1802 the island contained 145 dwelling-houses, and 1021 inhabitants: in 1821 it had 1080 inhabitants. On the northern angle of the island are some vestiges of a castle celebrated as having afforded refuge in 1306 to Robert Bruce. Near this building is a natural cavern called Bruce's Cave; at its entrance is a wall of lime and stone, which had evidently been erected for its defence.

No regular accounts of the climate of Antrim have been kept except at Belfast; and from these it appears that less rain falls here than is generally supposed, the

Antrim.

annual fall of rain, on an average of six complete years, being only 24·700 inches. The greatest height of the barometer between the years 1796 and 1809 was 31 inches, the lowest 28 inches. The greatest height of the thermometer during that period was 78°·80, the lowest 25°. The mean temperature of the northern coast of Antrim, near the town of Ballycastle, in latitude 55° 12′, as observed in the year 1788, by means of copious springs flowing from limestone soil, was 48°.

The estates in Antrim are in general freehold, being either immediate grants from the crown, or held under those grants: the only exceptions are the properties held under the see of Connor. Some of the estates are very large. The marquises of Hertford and Donegall, and the Antrim family, possess the fee of the greater part of the county. The estate of the first includes 11 parishes, containing nearly 80,000 English acres. The marquis of Donegall usually lets his lands on a fine for 61 years, or three lives: of late he has also granted many perpetuities. Most of the Antrim estate is let on perpetuity, in lots worth from L.1000 to L.4000 per annum. The other chief proprietors are Lord O'Neill, the countess of Massereene, Colonel Packenham, and Lord Templeton. The estate of the last is only leasehold under the marquis of Donegall. In January 1830 the total number of registered freeholders in this county for L.10 and upwards was 2037: in the same year the amount of the county cess was L.41,627. 9s. 11d.

The farms in Antrim are in general small; in the arable districts they generally vary from six to thirty acres, and the average rent is estimated at between 20s. and 35s. the Irish acre. The principal feature in the tillage system of a great part of the county is the potato fallow. The quantity of potato land is commonly regulated by the manure that can be collected: of late years the culture of potatoes has been much increased by the use of lime. After potatoes, wheat or oats are sown; if the latter, two or three crops are successively taken. When the ground is exhausted, potatoes are again planted, or the land is suffered to rest for a year or two, until it is covered with natural grass, in which state it is termed *lea*. The sowing of wheat is chiefly confined to the baronies of Belfast, Antrim, and Massereene. In 1763 there was not one flour-mill in the county. Flax is also sown after potatoes, except in the lower or northern part of the county. It bears a very small proportion in the general crop, less being sown than formerly. Flax-seed is rarely attempted to be saved. Of late years a considerable quantity of flax has been imported, chiefly from Holland. In 1830 the quantity of flax-seed imported at Belfast was 5637 hogsheads, the greater part of which was sown in the counties of Down, Armagh, and Derry. Barley is also sown in many places, but seldom in large quantities. The culture of beans is chiefly confined to the parishes of Island-Magee and Cairncastle; they are mostly exported to Scotland. Turnips or vetches are rarely sown. Kail are seldom planted as food for cattle. Such is the principal feature of the husbandry of the county of Antrim, which, however, from the improvements made by individuals, admits of many exceptions. This is strikingly exemplified in those districts where the tenants hold leases under liberal landlords;—there underwoods have been cleared off, bogs or marshes reclaimed into arable lands or meadow, and better and less cumbrous fences erected. Where the tenants hold at will, the lands are usually let at a rack-rent; and the smallest improvement by the occupier is almost certain of promoting a corresponding advance in his rent, of which he rarely receives advice till he waits on the land-agent, or is visited by his bailiff.

Productions.

The county at present (1830) perhaps possesses less timber than at any former period. The woods of Portmore and Glenarm have long since yielded to the axe; and the extensive plantings at Antrim, Templepatrick, Ballyclare, and Clementshill, have shared a similar fate. Many thriving plantations of trees have, however, been planted of late years near noblemen and gentlemen's seats, which already add much to the appearance of the face of the country. The plantations of Lord O'Neill at Shanescastle and Claggan, and those of the late Lord Macartney near Loughguile, are the most extensive. On the Hertford estate, near Loughneagh, many orchards are planted, which produce valuable varieties of the apple, the greater part of which is sold in Belfast; and considerable quantities are annually exported to Scotland.

The cattle of Antrim have no feature to distinguish them as being allied to any particular stock. Of late years considerable attention has been paid by gentlemen farmers to the improvement of the breed, by crossing with the Dutch, Leicester, and Ayrshire cattle, which is said to have improved much those kept for milk. In 1827 81,092 firkins of butter were exported from Belfast. Sheep are little attended to, and the few kept are mostly of an inferior kind. Few goats are kept, and those chiefly by cottagers. Pigs are reared and kept in considerable numbers, and on these the small farmers and cotters depend chiefly to make up their rents; so that it is not uncommon to find from two to eight or ten of these animals about each farmer's house. During the salting season, which may be said to commence in September and end in May, the number brought to market is immense. In the months of November, December, and January, 1826–27, upwards of 71,000 pigs were sold in Belfast, which, taken one with another, weighed 200 lbs., and varying in price from L.1. 12s. to L.2. 14s. per cwt.

Manufactures.

Antrim has long been distinguished for its linen manufacture; but latterly the manufacture of cotton has in some measure supplanted it, especially in the vicinity of the towns of Belfast, Lisburn, Antrim, and Carrickfergus. In 1771 there were 441 linen looms at work in Belfast; at present not one is employed. The cotton spinning by jennies was first introduced in 1777 by Robert Joy and Thomas M'Cabe of Belfast, under the direction of a female spinner from Glasgow. In the following year the latter gentleman also introduced the fly-shuttle. In the year 1800 it was computed that upwards of 13,000 people were *directly* employed in the cotton manufacture; and, including all manner of persons occupied in it in various ways, the number was at least 27,000, within a circuit of ten miles, comprehending, however, the towns of Belfast, Lisburn, and Carrickfergus. The number employed in the same space is now probably little short of twice that number. For many years after the introduction of the cotton business, the greater part of the yarn used for warps, and much of the weft yarn, were imported from Manchester or Scotland. Of late years cotton yarn has been exported from Belfast, though some is still imported, chiefly from Glasgow. In 1790, 39,603,451 lbs. of cotton wool were imported at Belfast; in 1826, 159,999,446 lbs. were imported at the same port, since which time the quantity has increased. In 1800 a weaver commonly earned, at weaving calico, from 10s. to 16s. per week; at present his earnings vary from 3s. 6d. to 5s. each week, for which he perhaps works about 17 hours per day.

The linen manufacture, though now much depressed, may still be considered the staple manufacture of Antrim. It is a peculiarity of this business, as it is established in Ireland, that it does not remove the peasant from the comforts and healthiness of rural life. In Antrim the weaver and the labourer of the soil are united in the same person.

Antrim. Many weavers have small farms, and only employ themselves in weaving during the intervals of their farming occupations; and almost all who pursue this trade possess gardens, and ground for potatoes. Many of the houses have from two to three looms, which cost from L.4 to L.5. 5s. each. Looms are also let out on hire by the year, at about 10s. Boys are hired out to attend looms: when they attend two looms, which is ample work for a boy of 12 or 15 years of age, the wages are about 16s. the half-year, with diet and lodging. A fine web, that is, a 16 or 18 hundred, is commonly woven in ten days or a fortnight. In some places the cloth is chiefly wrought by the fly-shuttle. Formerly the wages paid for this work varied from 14s. to 20s.; at present it is less: hence many weavers have become day-labourers. The price of linen yarn is also much reduced: that which formerly sold at 10d. or 1s. per hank often brings little more than the half of that price. This is in a great measure owing to the spinning of flax by machinery. Of late, cloth-merchants prefer cloth made from the yarn spun by the hand, and some refuse altogether to buy that made from the machine yarn. The best linen cloth is made in a district commonly called Kells-water, extending from Connor to near Randlestown. Nearly all the yarn wrought in this district is bought in Ballymena, and the cloth is sold in Belfast.

Fisheries. There are several considerable salmon fisheries on the rivers and coast of Antrim. One at Redbay, near Cushindall, another at the Point of Tor, near Fairhead; one at Ballycastle; one at Carrickareade; another between it and the Giant's Causeway, and another at the Bush-foot. The greatest is at the river Bann, at a place called the *Cutts*, near Coleraine. The price of salmon, when sold in the neighbouring towns, or Belfast, varies from 5d. to 10d. per lb. There is also a considerable eel fishery at Toome.

Antiquities. The antiquities of this county consist of cairns, caves, cromlechs, mounts or *forths*, ecclesiastical and military remains, and round towers. There are three round towers standing, viz. Antrim, which is perfect, and 95 feet high; Armoy, about four miles from Ballycastle, which is 44 feet high, part only being standing. Ram Island tower is 43 feet high, a portion having evidently fallen down. Until lately there was also a small round tower at Trumery: it fell in March 1829.

Population. In 1712 the number of dwelling-houses in the county of Antrim was 19,268; in 1726 their number was 18,916; in 1791 the houses were 30,314, of which 22,353 paid for one hearth, and the remainder were returned as inhabited by paupers, being unable to pay that tax. By the population returns of 1813, the county contained 42,258 dwelling-houses and 231,548 inhabitants; by the returns of 1821, 46,661 dwelling-houses and 262,860 inhabitants, 125,053 of whom were males, and 137,807 females.

Antrim has been supposed to contain a greater proportion of Protestants than any other county in Ireland; and of the Protestants a very great proportion are Presbyterians. The greater part of these are in connection with the general synod of Ulster, the others are *Remonstrants*, who separated from the synod in 1829; Burghers, Antiburghers, Covenanters, Independents, and a few Moravians. In several parishes, however, a decided majority are Roman Catholics: these parishes are Loyd, Culfeightoin, and Duneane. In several other parishes the number of Roman Catholics is also considerable.

Antrim, a town in Ireland, in the county of the same name, situated near the north end of Loughneagh, on the banks of the Six-mile-water, 12 miles north-west of Belfast, and 84 north of Dublin. It gives the title of earl to the noble family of MacDonnell, and prior to the Union in 1800 it was a potwalloping borough, and returned two members to parliament, under the patronage of the Skeffington family.

The town has been much improved of late years; and adjoining is the castle of the earl of Massereene, which was thoroughly repaired a few years ago. Markets are held each Thursday, and fairs in May and November. In 1821 the town contained 476 dwelling-houses and 2489 inhabitants. Near the town is a flour-mill and two paper-mills. On the 7th of June 1798 a smart action was fought in the town between the king's troops and a large body of rebels, in which the latter were defeated. In this action Lord O'Neill was mortally wounded by a pike.

ANTWERP, one of the provinces which compose the kingdom of the Netherlands. It is formed out of the two French departments of the two Drenthes, or out of the more ancient county of Antwerp, and barony of Mechlin. It is bounded on the north-east and north by North Brabant, on the south-east by Limburg, on the south by South Brabant, and on the west by West Flanders, from which it is divided by the Scheldt. It is an extensive plain, with scarcely an elevation; and the soil is a light sand mixed with a clayey loam, which is highly fertile. The land is protected from inundation by extensive embankments, and these dams inclose some of the most productive and highly cultivated spots, provincially known as *polders*. The northern and eastern part of the province is sandy and poor, and filled with morasses. The chief river is the Scheldt, which, before its junction with the sea, receives the Rupel, Nuthe, and Dyle. It is 2160 feet broad and 30 feet deep at Antwerp. There are two navigable canals, one from Brussels and the other from Louvain. The province is highly productive, both in agricultural and manufacturing commodities. The extent is 1004 square miles, or 642,560 acres. The inhabitants, at the last census, were 287,347. It is divided into three circles or arrondissements, 17 cantons, and 141 communes. This province elects five deputies to the states-general of the kingdom.

Antwerp, the chief city of the province of that name, as well as of a circle comprehending six cantons, 55 communes, and 131,169 inhabitants. The city is in the form of a crescent, on the right bank of the Scheldt; is strongly fortified, and protected by a citadel which connects the walls with the river. The houses are large and handsome, the streets tolerably wide, well paved, and at night well lighted. The most remarkable building is the Gothic cathedral, 500 feet in length and 240 in breadth, adorned by two of the best productions of the pencil of Rubens, with a tower 380 feet in height. Besides the cathedral, the church of St James, the exchange, the town-house, the easterling's-house, the theatre, and the hotel de charité, invite the attention of strangers. There are many manufactures of all kinds. The most considerable is that of silk goods. The breweries, distilleries, sugar-refineries, and tanneries, are numerous. One art, that of cutting diamonds, had been long practised here, and very extensively till the French ruled the country; and since their expulsion it has been once more revived. The city is well situated for foreign trade, from its easy connection by canals with the interior, and from its conveniencies for landing and shipping goods, to which last the docks constructed by the French vastly contribute. The trade has not, however, hitherto made rapid progress, but has gradually increased since the port has been opened. The inhabitants, at the last census, were 60,057. It is in lat. 51. 13. 22. N. and long. 4. 18. 14. E.

ANUBIS, a symbolical deity of the Egyptians, was regarded as the faithful companion of Osiris and of Isis. Temples and priests were consecrated to him, and his image was borne in all religious ceremonies. Cynopolis,

situated in the Lower Thebais, was built in honour of Anubis. The temple in which he was worshipped no longer exists. The priests celebrated his festivals there with great pomp, and consecrated the dog to him as his living representation. "Anubis," says Strabo, "is the city of dogs, the capital of the Cynopolitan prefecture. These animals are fed there on sacred aliments, and religion has decreed them a worship." An event, however, related by Plutarch, brought them into considerable discredit with the people. Cambyses having slain the god Apis, and thrown his body into a field, all animals respected it except the dogs, which alone ate of his flesh. This impiety diminished the popular veneration for them.

Cynopolis was not the only city which burned incense on the altars of Anubis. He had chapels in almost all the temples. On solemnities, his image always accompanied those of Isis and Osiris. Rome having adopted the ceremonies of Egypt, the emperor Commodus, to celebrate the Isiac feasts, shaved his head, and himself carried the god Anubis. The statue of this god was either of massive gold or gilt, as well as the attributes that accompanied him. Anubis signifies *gilded*. The denomination was mysterious; and the Egyptian priests, it would seem, had not given it without reason.

The signification of this emblematical deity is thus explained by Plutarch: "The circle which touches and separates the two hemispheres, and which is the cause of this division, receiving the name of *horizon*, is called *Anubis*. He is represented under the form of a dog, because that animal watches day and night." St Clemens of Alexandria, who was well informed in the mystic theology of the Egyptians, favours this explication. The two dogs, says he (the two Anubis), are the symbols of two hemispheres which environ the terrestrial globe. He adds in another place,—others pretend that these animals, the faithful guardians of men, indicate the tropics, which guard the sun on the south and on the north like porters.

According to the former of these interpretations the priests, regarding Anubis as the horizon, gilded his statue, to mark that this circle, receiving the first rays of the sun, appears sparkling with brightness on his rising, and that at his setting he reflects his last rays upon the earth. They said, in their sacred fables, that Anubis was the son of Osiris, but illegitimate. In fact, he only gives to the earth a borrowed light, and cannot be esteemed, like Horus, as the father of the day, or as the legitimate offspring of Osiris. It may be added, that the visible horizon, turning with the sun, is his inseparable companion.

In the latter of these explications, where Anubis represents the tropics, he is also the faithful guardian of Isis and Osiris. In fact, the course of the sun and of the moon is contained between the circles wherein the solstices are performed. They neither deviate to the right nor left. These limits, assigned by the Author of nature, might, therefore, in hieroglyphic language, be represented by a divinity with the head of a dog, who seemed to oppose the passage on the side of the two poles. The other opinion, notwithstanding, seems more natural, and to be more analogous to the ideas of the priests.

Upon the whole, it is reasonable to imagine that Anubis at first was only a symbolical image, invented by astronomers to give a sensible expression of their discoveries; that afterwards the people, accustomed to see it in their temples, which were the depositories of science, adored it as a deity; and that the priests favoured their ignorance by connecting it with their religion. The worship of Anubis being introduced, that of the dog became his emblem. Almost all the gods of the Gentiles have originated in this manner.

ANVIL, in smithery, and other manufactures of the malleable metals, is an instrument on which substances are laid for the purpose of being hammered.

For some purposes anvils are made of cast iron; but when the face of the anvil is required to possess great hardness, or a bright surface, it is made of wrought iron and faced with steel. The core or body of wrought iron anvils is prepared at the forge, where malleable iron is first formed into bars, or into masses for any particular purpose. The body of the anvil is formed by welding a number of smaller masses together under the forge-hammer. These are rude blocks of different sizes, according to the size of the anvil. Smaller masses are also furnished in this way, which the anvil-maker occasionally welds to the large blocks, for giving to the anvil any particular form.

The fire-place or hearth of the anvil-maker's forge is similar to the common smith's forge. His bellows are not double, like the latter. His fuel is cork, which produces a great heat without much flame. Adjacent to the hearth is a crane, which, turning upon a pivot, brings the heated masses of iron from the fire to the anvil. The latter is a large mass of cast metal, about 18 inches square on the face, and about a foot from the ground. When the core of the anvil to be formed is heated, the first thing is to make three square holes, one in the bottom, and one at each end of the anvil. These holes are about $1\frac{1}{4}$ inch long, 1 inch broad, and about 2 inches deep. They are for the purpose of receiving a bar of iron, which is connected with the crane by which the anvil is held in the fire, and by which it is turned and guided while forming with the hammers.

The common smith's anvil is generally made of seven pieces, namely, the core or body; the four corners, for the purpose of enlarging its base; the projecting end, which contains a square hole, for the reception of a set, or chisel, to cut off pieces of iron; and the seventh piece is the beak, or conical end, used for turning pieces of iron into a circular form, welding hoops, &c. These pieces are each separately welded to the core, and hammered so as to form a regular surface with the whole. When large pieces are required to be welded to the core, one fire is not sufficient to heat both at the same time. In this case two hearths are employed. The core and the piece are both raised to a welding heat. The piece being put into its place, is hammered by a quick succession of blows till it adheres. The whole is again heated and hammered till the due form is obtained. The hammering is performed by a number of men at the same time, each using a large swing-hammer. The blows follow each other in regular succession, great experience and care being required to prevent the hammers from coming in contact with each other.

When the anvil has received its due form, it now requires to be faced with steel. This is performed by first preparing the steel face to the size of the anvil. The anvil is then heated to a strong welding heat in one fire, while the steel facing is heated in another, but not so hot as the iron. The anvil is now brought out and placed in a proper position, and the facing is brought to it. The surfaces which are to be brought together are brushed, and the facing is then laid on and hammered as rapidly as possible, till it is closely united. The whole is finished by repeated heating and hammering.

The next process is that of hardening the anvil. This consists in heating the face, in particular, to a full red heat, and quenching it in cold water. When a stream of water can be employed it is better. Where this cannot be had, the mass of water should be great, and the anvil moved about as quick as possible. The facing should be laid on as thin as it can be firmly welded; when it is too thick it is apt to crack in the hardening.

D'Anville.

After hardening, the face is ground till it is perfectly even, and the edges made sharp or round, as may be required. When the anvil is required for planishing metals, it is polished with emery, and afterwards with crocus.

The smith's anvil is generally placed loose upon a wooden block, the root-end of an oak-tree being preferred. The anvils used in cutlery and for files are fastened into a large block of stone, which is doubtless better than having the anvil loose upon a small block. The more firmly the anvil is connected with the earth and the substance it stands upon, the greater will be the effect of the blow of the hammer.

ANVILLE, Jean Baptiste Bourguignon d', a French geographer of the highest eminence, and perhaps the most celebrated in modern times. He was born at Paris on the 11th of July 1697. His passion for geographical research displayed itself from his earliest years. At the age of 12, while reading the Latin authors at college, he amused himself with drawing maps of the countries which they described. While he was thus busily employing himself one day in the class, his master observed and was about to punish him; but upon casting his eye upon the performance, he immediately judged him to be rather deserving of encouragement. D'Anville from this time devoted himself entirely to geography, particularly that of the ancient world; and at the age of 22 he began to delineate maps which attracted the attention of the most eminent geographers.

There are two modes by which problems in geography may be solved; one mathematically, by astronomical observation or geometrical measurement; the other historically, by the distances of places inferred from the narrative of historians and travellers. The former is certainly the most satisfactory, and would supersede every other, could it be extended over the whole surface of the globe. But, notwithstanding the splendid progress made since the era of D'Anville, it is still far from such a degree of perfection. In all countries the bulk of the positions must be filled up, and in some the whole must be constructed from mere historical materials. Perhaps there is no department of science which requires greater extent of knowledge and accuracy of judgment. The variety of sources out of which the materials must be drawn is almost infinite; and their application is equally nice and difficult. It must be regulated by a complete acquaintance with all the modes of measurement used by all nations; by a careful notice of those errors and contradictions which naturally arise from a partial and limited observation; and by the marking of certain delicate processes in the human mind, by which space and distance are sometimes diminished, and more frequently exaggerated. In the skilful geographer, sound natural judgment, enlightened by experience, creates, as it were, a new sense, which enables him to see consistency amid a labyrinth of contradictions, and to elicit truth from a multitude of statements that are all erroneous. This art may be said to have originated with D'Anville, and to have been brought by him to its highest perfection.

The course of study on which D'Anville entered was truly immense. Works professedly geographical formed the least part of it; those of all the ancient and modern historians, travellers, narrators of every description, were assiduously examined. He studied, but only for the sake of the occasional geographical lights which they afforded, the philosophers, orators, and poets; for it was remarked that, in perusing these masterpieces of human genius, he was totally indifferent to every thing which did not tend to fix a geographical position. The object of this immense labour was to effect a complete reform in the science of geography; to banish the system of copying blindly from preceding maps, and never to fix a single position without a careful examination of all the authorities upon which it rested. By this process he detected many and great errors in the works of his most celebrated predecessors, while his own accuracy was soon attested on all sides by the travellers and mariners who had taken his works as their guide. His principles led him also to another innovation, which was that of omitting every name for which there existed no sufficient authority. The public were at first amazed at seeing vast spaces, which had before been covered with countries and cities, suddenly reduced to a perfect blank; but they soon recognised that this was the only accurate course, and that the defect lay in the science, not in the geographer.

D'Anville was at first employed in the humbler task of illustrating by maps the works of different travellers, such as Marchais, Charlevoix, Labat, and Duhalde. The question respecting the figure of the earth coming to be much agitated, he published, in 1735 and 1736, two treatises, with a view to illustrate it. But this attempt to solve a geometrical problem by historical materials was eminently unsuccessful. Maupertuis having gone to measure a degree within the polar circle, the result was found directly opposite to our geographer's prediction. This, however, was considered by the intelligent public rather as fixing limits to his mode of investigation, than as implying any want of diligence and ability in its employment.

Any loss of reputation which this failure might occasion was completely retrieved by his map of Italy, published in 1743. It was marked by a species of investigation, often employed by D'Anville with peculiar success. This consisted in the application of ancient materials to correct the existing geography. By the diligent study of the Latin authors, he was enabled to trace numerous errors which had crept into the delineation of this interesting country. A trigonometrical survey which Pope Benedict XIV. almost immediately after caused to be made in the Ecclesiastical States, confirmed, in a surprising degree, all these alterations. On this occasion he first set the example, which cannot be too much applauded, of accompanying the map with a memoir, exhibiting a view of the data on which it had been constructed.

He now applied himself to ancient geography, always his favourite department, and the aspect of which, under his hands, was soon completely changed. He illustrated successively, by maps, all the countries known to the ancients, among which Egypt attracted his peculiar attention. To render these labours more extensively useful, he published in 1768 an *Abridgement of Ancient Geography*. His attention was finally turned to the middle ages, which were illustrated by his *States formed in Europe after the Fall of the Western Empire*, and by some other works equally learned. Entirely devoted to geographical inquiries, the appearance of his successive publications formed the only events by which his life was diversified. From causes which are not explained, he was late in being admitted into the literary societies. In 1754, at the age of 60, he became a member of the Academy of Inscriptions and Belles Lettres, whose Transactions he enriched with many papers. In 1775 he received the only place in the Academy of Sciences which is allotted to geography; and in the same year he was appointed, without solicitation, first geographer to the king. But these honours came too late to illustrate a life which was now drawing to its utmost verge. His last employment consisted in arranging his collection of maps, plans, and geographical materials. It was the most extensive in Europe, and had been purchased by the king, who, however, left him the use of it during his life. This task performed, he sunk into a total imbecility, both of mind and

body, which continued for two years, and ended only with his death in January 1782, when he had nearly reached the great age of 85.

D'Anville, with the qualities which form the great geographer, united all the essentials of an honourable and worthy character. The advancement of the science to which he had devoted himself formed almost the sole passion of his life; and, mingling little with society, he contracted peculiarities which solitary study is but too apt to engender. He talked with little interest on any subject except geography. This topic necessarily led to that of his own discoveries, on which he was never weary of expatiating. He boasted without any reserve of the services which he had rendered to that science, using not unfrequently the expression of Augustus, "I found it of brick, and left it of marble." He, however, did full justice to the merit of those who excelled in other branches of knowledge; and to such as furnished him with materials for his researches, his gratitude was unbounded.

We shall subjoin a list of the numerous memoirs and dissertations composed by D'Anville, of which some were published separately, and others in the Transactions of the academies. The following were published separately:

1. Mémoire pour faire la carte du diocese de Lizieux.
2. Mémoire pour la révision de cette carte.
3. Mémoire instructif pour dresser des cartes particulières, avec une carte *in folio.*
4. Observations sur la carte du Paraguay, avec une carte d'une demi-feuille.
5. Proposition d'une mesure de la terre, avec une carte d'une demi-feuille.
6. Mesure conjecturale de la terre sur l'équateur, avec une carte d'une demi-feuille.
7. Réponse de M. d'Anville au mémoire contre cette mesure.
8. Lettre au P. Castel sur le Kamtchatka, avec une carte d'un quart de feuille.
9. Article de la géographie, tiré de l'Histoire Ancienne de Rollin.
10. Nomenclature alphabétique de l'Italie, tirée de l'Histoire Romaine de Rollin.
11. Eclaircissemens sur l'ancienne Gaule, avec deux cartes de deux demi-feuilles.
12. Lettre à M. de la Roque, sur un lieu nommé anciennement *Chora.*
13. Mémoire pour dresser des cartes d'un canton renfermant dix ou douze paroisses.
14. Analyse de l'Italie, avec trois cartes de 4 feuilles *in folio.*
15. Mémoire pour dresser une carte de la généralité de Soissons.
16. Dissertations sur l'ancienne Jérusalem, avec une carte de demi-feuille.
17. Lettres sur la carte de l'Amérique méridionale, avec une carte de 3 feuilles *in folio.*
18. Eclaircissemens sur la carte de l'Inde, avec deux cartes de 5 feuilles *in folio.*
19. Mémoire sur la carte du Canada, etc., avec une carte de 4 feuilles *in folio.*
20. L'article Vents Etésiens, tiré de l'Encyclopédie.
21. Analyse de la carte des côtes de la Grèce, avec une carte *in folio.*
22. Notice de l'ancienne Gaule, avec une carte *in folio.*
23. Mémoires sur l'Egypte ancienne et moderne, avec 5 cartes, dont 2 *in folio.*
24. Géographie ancienne abrégée, avec 9 cartes *in folio.*
25. Traité des mesures itinéraires.
26. Etats formés en Europe, avec une carte *in folio.*
27. L'Empire Turc.
28. L'Empire de Russie.
29. Eloge de M. Gravelot, frère de M. d'Anville, tiré du Nécrologe.
30. Antiquité de l'Inde.
31. Mémoire sur la Chine.
32. Considérations sur la composition des cartes géographiques.
33. Mémoire sur la Mer Caspienne, avec une carte *in 4to.*
34. L'Euphrate et le Tigre, avec une carte *in folio.*
35. Mémoires sur les cartes de l'ancienne Gaule.
36. Mémoire sur la vallée de Tempé.

The following appeared in the *Transactions of the Academy of Belles Lettres:*—

1. Sur le pas militaire du soldat Romain et celui de soldat Français.
2. Sur la nation des Gêtes.
3. Sur les sources du Nil, avec une carte.
4. Sur les rivières de l'Afrique, avec une carte.
5. Sur la mesure du Schène Egyptien, avec une carte.
6. Sur la mesure de la terre par Eratosthène.
7. Sur la détermination de plusieurs positions dans le Levant.
8. Découverte d'une cité dans l'ancienne Gaule, avec une carte.
9. Sur un monument ancien de la Médie.
10. Sur la position de Babylone, avec une carte.
11. Description de l'Hellespont, avec une carte.
12. Sur le mille Romain, avec une carte.
13. Sur le Portus Itius, avec une carte.
14. Sur les villes de Taurunum et de Singidunum, avec une carte.
15. Description de la Dace de Trajan, avec une carte.
16. Sur le Li, mesure itinéraire des Chinois.
17. Sur quelques points de géographie dans l'Arabie Heureuse.
18. Sur la différence de latitude et de longitude entre Alexandria et Syéné, avec une carte.
19. Sur le pays d'Ophir, avec une carte.
20. Sur la situation de Tartessus, avec une carte.
21. Sur le Golfe Persique, avec une carte.
22. Sur l'étendu de l'ancienne Rome, avec une carte.
23. Sur les peuples qui habitent la Dace de Trajan.
24. Du rempart de Gog et de Magog, avec une carte.
25. Sur deux villes nommées Justiniana, avec une carte.
26. De la mesure itinéraire Arménienne.
27. Description du Golfe d'Ambracie, avec une carte.
28. Sur l'Isle de Cypre, avec une carte.
29. Sur l'expédition d'Héraclius en Perse, avec une carte.
30. Sur la Sérique des anciens, avec une carte.
31. Limites du monde connu des anciens, avec une carte.
32. Du Lac Asphaltite ou Mer Morte, avec une carte.
33. Examen critique d'Hérodote sur la Scythie, avec une carte.
34. Sur la Mer Erythrée, avec une carte.
35. Sur l'étendue de Constantinople, comparée à celle de Paris, avec une carte.
36. Des fleuves du nom d'Araxe.
37. Sur la navigation de Pythéas à Thulé.
38. Sur les noms de peuples et de villes cités dans un fragment du 91me livre de Tite-Live, avec une carte.

And the following in the *Transactions of the Academy of Sciences:*—

Mémoire pour corriger la latitude de la Mesopotamie, avec une carte. (E.)

D'Anville || Anweiler.

ANWEILER, a canton in the district of Landau, in the circle of the Rhone, belonging to the kingdom of Bavaria; containing one city and 29 villages. The capital of the canton is of the same name. It contains 1841 persons, employed in various manufactures. Near it are the ruins of the castle of Greifels, where, under the French emperors of Germany, the crown jewels were kept, and

where our Richard Cœur de Lion, in 1193, was detained as a prisoner.

AONIDES, in *Mythology*, one of the many appellations of the muses; so called from Aonia, a part of ancient Bœotia.

AORASIA, in *Antiquity*, the invisibility of the gods. The word is Greek, αορασια, and derived from α priv. and ὁραω, *I see*. The opinion of the ancients with regard to the appearance of the gods to men was, that they never showed themselves face to face, but were known from their backs as they withdrew.

AORIST, among grammarians, a tense peculiar to the Greek language, comprehending all the tenses, or rather expressing action in an indeterminate manner, without any regard to past, present, or future.

AORISTIA, in the sceptic philosophy, denotes that state of the mind wherein we neither assert nor deny any thing positively, but only speak of things as seeming or appearing to us in such a manner. The aoristia is one of the great points or terms of scepticism to which the philosophers of that denomination had continual recourse by way of explication or subterfuge. Their adversaries, the dogmatists, charged them with dogmatizing, and asserting the principles and positions of their sect to be true and certain.

AOSTA, a duchy of Piedmont, separated by the Alps from Savoy and the Valais, and bounded on the east and south by the Navarese and the provinces of Biella and Yvry. The country is in general mountainous; but there are several valleys of great extent, particularly the *Val d'Aosta*. By the industry of the inhabitants these low grounds are very fruitful in wine, oil, and pasture; and the mountains abound in iron and copper.

Aosta, the chief town of the foregoing duchy, and the see of a bishop. It is situated on the river Doria, at the foot of the Alps, where the great commercial roads from Savoy and the Valais to Piedmont, over the Great and Little St Bernard, meet each other. The town, though large, is meanly built and thinly peopled. It is remarkable for several monuments of the Romans, and for being the birthplace of Anselm, archbishop of Canterbury. Long. 7. 33. E. Lat. 45. 58. N.

APÆDUSIA denotes ignorance or unskilfulness in what relates to learning and the sciences. Hence also persons uninstructed and illiterate are called *apædeutæ*. The term *apædeutæ* was particularly used among the French in the time of Huet, when the men of wit at Paris were divided into two factions, one called by way of reproach *apædeutæ*, and the others *eruditi*. The *apædeutæ* are represented by Huet as persons who, finding themselves either incapable or unwilling to undergo a severe course of study in order to become truly learned, conspire to decry learning, and turn the knowledge of antiquity into ridicule, thus making a merit of their own incapacity. The *apædeutæ* in effect were the men of pleasure, the *eruditi* the men of study. The *apædeutæ* in every thing preferred the modern writers to the ancient, to supersede the necessity of studying the latter. The *eruditi* derided the moderns, and valued themselves wholly on their acquaintance with the ancients.

APAGOGE, in the Athenian law, the carrying a criminal taken in the fact to the magistrate. If the accuser was not able to bring him to the magistrate, it was usual to take the magistrate along with him to the house where the criminal lay concealed or defended himself.

Apagoge, in *Mathematics*, is sometimes used to denote a progress or passage from one proposition to another, when the first, having been once demonstrated, is afterwards employed in the proving of others.

APAGOGICAL Demonstration, an indirect way of proof, by showing the absurdity of the contrary.

APALACHIAN Mountains. See Allegany Mountains.

APANTHROPY, in *Medicine*, denotes a love of solitude, and aversion for the company of mankind. Apanthropy is by some reckoned among the symptoms, by others among the species or degrees, of melancholy; and also passes for an ill indication in leucophlegmatic cases.

APARITHMESIS, in *Rhetoric*, denotes the answer to the protasis, or proposition itself. Thus, if the protasis be, *Appellandi tempus non erat*,—the aparithmesis is, *At tecum anno plus vixi*.

APARTISMENUS, in ancient poetry, an appellation given to a verse which comprehended an entire sense or sentence in itself. This is sometimes also written *apartemenus*, *i. e.* suspended, as not needing any following verse.

APATHY, among the ancient philosophers, implied an utter privation of passion, and an insensibility of pain. The word is compounded of α priv. and παθος, *affection*. The Stoics affected an entire apathy: they considered it as the highest wisdom to enjoy a perfect calmness or tranquillity of mind, incapable of being ruffled by either pleasure or pain. In the first ages of the church the Christians adopted the term *apathy* to express a contempt for all earthly concerns, a state of mortification such as the gospel prescribes. Clemens Alexandrinus, in particular, brought it exceedingly in vogue; thinking thereby to draw the philosophers to Christianity who aspired after such a sublime pitch of virtue.

APATURIA, in *Antiquity*, a solemn feast celebrated by the Athenians in honour of Bacchus. The word is usually derived from απατη, *fraud*. It is said to have been instituted in memory of a fraudulent victory obtained by Melanthus, king of Athens, over Xanthus, king of Bœotia, in a single combat, which they agreed upon, to put an end to a debate between them relating to the frontiers of their countries. Hence Budæus calls it *festum deceptionis*, the feast of deceit.

Other authors give a different etymology of this feast. They tell us that the young Athenians were not admitted into the tribes on the third day of the apaturia, till their fathers had first sworn that they were their own children; and that till that time they were supposed in some measure to be without fathers, απατορες; whence the feast, say they, took its name. Xenophon, on the other hand, informs us that the relations and friends met on this occasion, and joined with the fathers of the young people who were to be received into the tribes; and that from this assembly the feast took its name; that in απατουρια, the α, far from being a privative, being here a conjunctive, signifies the same thing with ὁμου, *together*. This feast lasted four days: the first day, those of the same tribe made merry together; and this they called δορπια. The second day, which they called αναρρυσις, they sacrificed to Jupiter and Minerva. The third day, which they called κουρεωτις, such of their young men and maids as were of age were admitted into their tribes. The fourth day they called επιβδα.

APAULIA, in *Antiquity*, the third day of a marriage solemnity. It was thus called because the bride, returning to her father's house, did απαυλιζεσθαι του νυμφιου, lodge apart from the bridegroom. Some will have the apaulia to have been the second day of the marriage, viz. that whereon the chief ceremony was performed; thus called by way of contradistinction from the first day, which was called προαυλια. On the day called απαυλια (whenever that was), the bride presented her bridegroom with a garment called απαυληπηρια.

APE. See Mammalia, *Index*.

APELLES, one of the most celebrated painters of an-

tiquity. He was born in the island of Cos, and flourished in the time of Alexander the Great, with whom he was in high favour. He executed a picture of this prince holding a thunderbolt in his hand,—a piece finished with so much skill and dexterity, that it used to be said there were two Alexanders; one invincible, the son of Philip; the other inimitable, the production of Apelles. Alexander gave him a remarkable proof of his regard; for when he employed Apelles to draw Campaspe, one of his mistresses, having found that he had conceived an affection for her, he resigned her to him; and it was from her that Apelles is said to have drawn his Venus Anadyomene.

One of Apelles's chief excellencies was his making his pictures exactly resemble the persons represented; but what is called *grace* was the characteristic of this artist. His pencil was so famous for drawing fine lines, that Protogenes discovered by a single line that Apelles had been at his house. Protogenes lived at Rhodes: Apelles sailed thither, and went to his house with great eagerness to see the works of an artist who was known to him only by name. Protogenes was gone from home, but an old woman was left watching a large piece of canvass, which was fitted in a frame for painting. She told Apelles that Protogenes was gone out; and asked him his name, that she might inform her master who had inquired for him. "Tell him," said Apelles, "he was inquired for by this person;" at the same time taking up a pencil, he drew on the canvass a line of great delicacy. When Protogenes returned, the old woman acquainted him with what had happened. That artist, upon contemplating the fine stroke of the line, immediately pronounced that Apelles had been there, for so finished a work could be produced by no other person. Protogenes, however, himself drew a finer line of another colour, and, as he was going away, ordered the old woman to show that line to Apelles if he came again; and to say, "This is the person for whom you are inquiring." Apelles returned and saw the line: he would not for shame be overcome; and therefore, in a colour different from either of the former, he drew some lines so exquisitely delicate that it was utterly impossible for finer strokes to be made. Protogenes now confessed the superiority of Apelles, flew to the harbour in search of him, and resolved to leave the canvass with the lines on it for the astonishment of future artists.

Apelles showed great liberality of mind towards Protogenes. With ideas enlarged by education and literature, he was incapable of harbouring little jealousies of noble competitors; on the contrary, he was the first who made the works of Protogenes to be valued as they deserved among the Rhodians. He acknowledged that Protogenes was in some respects superior to himself; but that in one particular he himself excelled, viz. in knowing when to take his hand from the picture, an art which Protogenes had not yet learned, and therefore over-worked his pieces. Apelles equally disapproved of too elaborate diligence, or too hasty negligence in execution. A studied work of Protogenes he esteemed less on the one account; and on the other, when a silly painter once brought him a picture, and said, "This I painted in a hurry," he replied, "Though you had not told me so, I perceived it was painted in haste; but I wonder you could not execute more such pieces in the same time."

There are two stories related of Apelles, which show him to be at once an artist of modesty, in amending even trifling improprieties, when pointed out to him by competent judges, and yet of self-confidence sufficient to make him know the perfection and value of his own paintings. It was customary with Apelles to expose to public view the works which he had finished, and to hide himself behind the picture, in order to hear the remarks passed on it by persons who chanced to view it. He once overheard himself blamed by a shoemaker for a fault in the slippers of some picture: he corrected the fault which the man had noticed; but on the day following the shoemaker began to animadvert on the leg; upon which Apelles with some anger looked out from behind the canvass, and bade him keep to his own province, "Ne sutor ultra crepidam." It is well known that Alexander forbade any one besides Apelles to paint his portrait. We are not, however, to conclude from this that Alexander was a more skilful judge of painting than he was of poetry. Like Augustus, he cherished the fine arts more from vanity than taste. A remarkable proof is given of this prince's inability to discern merit, and of the painter's freedom in expressing the mortification he felt, when a work of his was not sufficiently commended. "Alexander," says Ælian, lib. ii. c. 3. Var. Hist. "having viewed the picture of himself which was at Ephesus, did not praise it as it deserved. But when a horse was brought in, and neighed at seeing the figure of a horse in the picture, as though it had been a real horse, *O king!* said Apelles, *this horse seems to be by far a better judge of painting than you.*" It happened more than once that the horses drawn by him were mistaken for real ones, by living horses which saw and neighed at the pictures. In his finishing a drawing of this animal, a remarkable circumstance is related of him. He had painted a horse returning from battle, and had succeeded to his wishes in describing every other mark that could indicate a mettlesome steed impatient of restraint; there was wanting nothing but a foam of a bloody hue issuing from the mouth. He again and again endeavoured to express this, but his attempts were unsuccessful. At last, with vexation, he threw against the reins of the horse a sponge which had in it many colours; a mixture of which coming out of the sponge, and tinging the reins, produced the very effect desired by the painter.

The works of Apelles were all admired; but the most celebrated were the picture of Alexander in the temple of Diana at Ephesus, and that of Venus emerging from the sea. Alexander was drawn with thunder in his hand; and such relief was produced by the *chiaro-scuro* in this piece, that the fingers seemed to shoot forward, and the thunderbolt to be out of the picture. His Venus Αναδυομενη was esteemed the most exquisite figure which the pencil could create.

APELLITES, Christian heretics in the second century, who affirmed that Christ received a body from the four elements, which at his death he rendered back to the world, and so ascended into heaven without a body.

APENE, in *Antiquity*, a kind of chariot wherein the images of the gods were carried in procession on certain days, attended with a solemn pomp, songs, hymns, dancing, &c. It was very rich, made sometimes of ivory, or of silver itself, and variously decorated.

APENNINUS, now the *Apennine*, a mountain, or ridge of mountains, running through the middle of Italy, from north-west to south-west, in the form of a crescent (Pliny); beginning at the Alps in Liguria, or the Rivierra di Genoa, and terminating at the Strait of Messana, or at Reggio, and the promontory Leucopetra, and separating, as by a back or ridge, the Adriatic from the Tuscan Sea. (Pliny, Strabo, Ptolemy, Polybius, Vitruvius.) See ITALY.

APENRADE, a city in the duchy of Sleswick, the chief of the bailiwick of the same name. It contains 309 houses and 2850 inhabitants. The harbour is shallow, and vessels must discharge below the town. The roadstead at the entrance is without shelter. It is in long. 9. 31. E. lat. 55. 2. N.

APERTURE, the opening of any thing, or a hole or cleft in any continuous object.

APERTURE, in *Geometry*, the space between two right lines which meet in a point and form an angle.

APERTURE, in *Optics*, a round hole in a turned bit of wood or plate of tin, placed within the side of a telescope or microscope, near to the object-glass, by means of which more rays are admitted, and a more distinct appearance of the object is obtained.

APETALOSE, or APETALOUS, among botanists, an appellation given to such plants as have no flower-leaves.

APEX, the vertex or summit of any thing.

APEX, in *Antiquity*, the crest of a helmet, but more especially a kind of cap worn by the flamens.

APEX, among grammarians, denotes the mark of a long syllable, falsely called a *long accent*.

APHÆRESIS, in *Grammar*, a figure by which a letter or syllable is cut off from the beginning of a word. Thus *ciconia*, by aphæresis, is written *conia; contemnere, temnere; omittere, mittere*, &c.

APHEK, the name of several cities mentioned in Scripture. 1. Aphek in the tribe of Judah, where the Philistines encamped when the ark was brought from Shiloh, which was taken by them in battle. 1 Sam. iv. 1, 2, &c. It is thought to be the same with Aphekah, mentioned in Josh. xv. 53. 2. Aphek in the valley of Jezreel, where the Philistines encamped while Saul and his army were near Jezreel, upon the mountains of Gilboa. 1 Sam. xxix. 1, &c. 3. Aphek, a city belonging to the tribe of Asher, near the country of the Sidonians. Josh. xix. 30, and xiii. 4. 4. Aphek, a city of Syria, one of the principal in Ben-hadad's kingdom, near which the battle was fought between Ahab and Ben-hadad, wherein the Syrians were worsted, and whereof, as they retreated with precipitation into the city, the walls fell upon them, and crushed in pieces 27,000. 1 Kings, xx. 26, *et seq.* This city lay between Heliopolis and Byblus.

APHELIUM, or APHELION, in *Astronomy*, is that point in any planet's orbit in which it is farthest distant from the sun, being that end of the greater axis of the elliptical orbit of the planet most remote from the focus where the sun is.

APHIOM, KARAHISSART, a town of Natolia, in Asiatic Turkey. It is named Aphiom because it produces a great deal of opium, called *aphiom* by the Turks. Long. 30. 26. E. Lat. 38. 35. N.

APHIS, the PUCERON, VINE-FRETTER, or PLANT-LOUSE. See ENTOMOLOGY, *Index*.

APHLASTUM, in the ancient navigation, a wooden ornament, shaped like a plume of feathers, fastened on the goose's or swan's neck used by the ancient Greeks in the heads of their ships. The aphlastum had much the same office and effect in a ship that the crest had on the helmet. It seems also to have had this further use, viz. by the waving of a party-coloured riband fastened to it, to indicate from what quarter the wind blew.

APHONIA, among physicians, signifies a suppression or total loss of voice. It is never a primary disease, but a consequence of many different disorders. The cure is to be effected by removing the disorder from whence the aphonia proceeds.

APHORISM, a maxim or principle of a science, or a sentence which comprehends a great deal in a few words. The word comes from *αφοριζω, I separate.*

APHRACTI, in the ancient military art, denotes open vessels, without decks or hatches, furnished only at head and stern with cross planks, whereon the men stood to fight.

APHRODISIA, in *Antiquity*, festivals kept in honour of Venus, the most remarkable of which was that celebrated by the Cyprians. At this solemnity several mysterious rites were practised: all who were initiated to them offered a piece of money to Venus as a harlot, and received as a token of the goddess's favour a measure of salt and a φαλλος; the former, because salt is a concretion of sea-water, to which Venus was thought to owe her birth; the latter because she was the goddess of wantonness.

APHRODISIACS, among physicians, medicines which were supposed to increase the quantity of semen, and create an inclination to venery.

APHRODITE, in *Mythology*, a name of Venus, derived from *αφρος, froth;* because, according to the poets, Venus is supposed to have been produced from the froth or foam of the sea.

APHTHARTODOCETÆ, a sect, sworn enemies of the council of Chalcedon. The word is derived from *αφθαρτος, incorruptible*, and *δοκεω, I imagine;* and was given them because they imagined that the body of Jesus Christ was incorruptible and impassible, and not capable of death. They arose among the Eutychians, and made their appearance in the year 535.

APIARY. Under the article BEE, in this work, directions will be given at considerable length as to the management of an apiary, and various methods detailed of procuring honey and wax from the hive without destroying the bees themselves. The most economic mode of attaining these ends deserves more attention as a national object than it has in general received in this country. It appears, from the returns of the custom-house, that England pays annually to the north of Germany from L.40,000 to L.50,000 sterling for the wax and honey which are imported from thence, and which might very easily be raised by a more extended and judicious cultivation of bees at home. Greater attention to this useful appendage to the cottage would not only be productive of commercial advantage, but would tend to improve the condition of the lower order of peasantry. It is not generally known, indeed, what profitable returns may be obtained, at a trifling expense of time and labour, by very simple processes. Mr Huish, the author of a valuable practical treatise on the management of bees, has made a calculation, from which he infers, that even supposing the first cost of a swarm to be one guinea, which is the price in the places where they are sold the dearest, the cottager is almost certain, by proper care and management, of clearing, in five years, a net produce of nearly L.60, and of having besides, at the end of that period, ten good stocks of bees in his garden.

The principal objects to be attained in the construction and management of an apiary, are to secure the prosperity and multiplication of the colonies; to increase the amount of their productive labour; and to obtain their products with facility, and with the least possible detriment to the stock. The apiary should afford to the bees the best shelter against moisture and the extremes of heat and of cold, and especially against sudden vicissitudes of temperature; it should protect them against their numerous enemies; it should afford them every facility of constructing their combs, and of rearing their young; it should allow of every part of the combs being occasionally inspected, and being capable of removal when requisite; and, while due attention is paid to economy, it should be made of materials that will insure its durability. Much ingenuity has been displayed by different apiarians in the construction of hives which should unite in the greatest possible degree all these advantages. Although it be in vain to hope that every one of these objects can at once be perfectly attained, yet there is still great room for improvement on the hives that are at present in common use; and we shall here point out a few of the more recent modes of construction.

While some cultivators of bees have been chiefly anxious to promote their multiplication, and to prevent the escape of the swarms in the natural way, by procuring what they have termed *artificial swarms*,—which they effected by separating a populous hive, previous to its swarming, into two parts, and allowing to each greater room for the extension of their works; others have contemplated only the abundance of the products which they yielded, and the facility of extracting them from the hive, without showing any particular solicitude as to the preservation of the bees themselves. Another class of apiarians have, on the other hand, had it more particularly in view to facilitate the prosecution of researches in the natural history and economy of bees. The hive invented by Mr Huber is peculiarly calculated for the last of these objects, and its construction is founded on an accurate knowledge of the habits of these insects. He has given it the name of *ruche en livre ou en feuillets*, from its opening and shutting somewhat in the manner of the leaves of a book. This *book* or *leaf hive* is composed of from eight to twelve square wooden frames, placed vertically, and joined together sidewise like the hoops of a cask. Each frame consists of two uprights, one inch in thickness, a foot in height, and an inch and a third in width, connected by an upper and lower cross bar, ten inches long, and of the same breadth and thickness as the former; so that all the frames may be joined together, without leaving any interval. The two external frames are closed each by a pane of glass, which is covered by a shutter on the outside; and the whole is properly secured in its place, and further protected by an external cover. An aperture must of course be left in the lower part of one of the frames to serve as a door. In order to determine the bees to construct their combs in the plane of each leaf, a small piece of honeycomb is fixed, by means of pegs, to the top of each in the proper position, as it is well known that bees always complete their work in the direction in which they find it begun, unless they meet with some insurmountable obstacle. A proper distance is thus preserved between the lateral surfaces of the perpendicular combs; and the external ones, being only three or four lines distant from the glass panes, may be easily inspected by opening the shutters; and also by opening in succession the different divisions of the hive, both surfaces of every comb may at pleasure be fully brought into view. No difficulty is experienced in introducing swarms into hives of this construction; and after the lapse of a few days, when the colony is fully established, the bees will very patiently submit to be daily inspected.

Mr Huber's hive is exceedingly well calculated for producing artificial swarms on the principle of Schirach's discovery, of which a full account will be given in the article Bee. It allows us to judge by inspection whether the population is sufficient to admit of division,—if the brood is of the proper age,—and if males exist, or are ready to be produced, for impregnating the young queen; all which circumstances are of material consequence to the success of the operation. It is essential that some of the larvæ should not have been hatched above three days before this attempt is made. The frames must then be gently separated at the middle of the hive, and two empty frames be introduced in the interval between the former; each of these new frames having a partition which closes them completely, so as to enable the two portions to be entirely separated without leaving any opening. The door of that portion in which the queen happens to be at this time may remain open, but the one belonging to the other part must be closed, so as to retain the bees that have no queen prisoners for 24 hours, allowing still, however, sufficient circulation of air. After this interval of time they appear to have forgotten their queen, at least they are no longer anxious to seek for her, but bestow all their solicitude in the education of the larvæ, so as to convert a certain number of them into queens to supply the loss they have sustained. This they accomplish in ten days or a fortnight after the operation. The two colonies are now perfectly distinct, and are never found afterwards to intermix.

Another advantage attending a hive of this construction consists in its enabling us to force the bees to produce a much greater quantity of wax than they would naturally do. The interval which separates the combs when the bees have not been disturbed in their operations is constantly the same, namely, about four lines. Were they too distant, it is evident that the bees would be much dispersed, and unable to communicate their heat reciprocally, and the brood would not be preserved in a sufficient degree of warmth. Were the combs too close, on the contrary, the bees could not freely traverse the intervals, and the work of the hive would suffer. It is evident that we may avail ourselves of this instinct, and, by separating farther asunder the combs that are already built, induce the bees either to extend the breadth of those they had begun, or to build others in the interval, if sufficient space be allowed them for this purpose. Thus, by interposing three empty frames, one between every alternate interval of the combs in a hive containing six combs, three additional combs, if the proper season be chosen, will be obtained at the end of a week; and if the weather continue favourable, the operation may be repeated, and the same number of additional combs procured the week after.

The principal obstacles to the general employment of Mr Huber's hives are the expense of constructing them, and the greater degree of attention which they perhaps require from the cultivator. It has also been objected that the flatness of the roof was prejudicial, by allowing the moisture which exhales from the bees to collect at the top, and to fall in drops at different parts, to the great injury of the subjacent contents of the hive. Feburier proposes therefore the employment of frames in the form of a trapezium, so that the roof shall be considerably inclined to the horizon. He borrows this shape from Bosc, whose hive consists, however, only of two boxes joined together sidewise, and separable in order to form artificial swarms. This was an improvement upon Gelieu's hive, which was formed of two square boxes united laterally. Delator had recommended a still more simple form than that of Bosc, though less convenient; namely, that of a triangle resting on its base. Mr Ravenel's hive consists of three square boxes instead of two; Mr Scrain's is also made up of three boxes, but they are low and of great length, and are joined endwise,—a communication being established between them by apertures made in the divisions which separate the boxes. It is now, however, well established, that partitions of any kind are detrimental to the prosperity of the colony. The same objection applies, though perhaps in an inferior degree, to the system of storied hives, or those which are divided into stories one above another. A great variety of the latter description, however, have been recommended by different cultivators. In France they are known by the name of *ruches en hausses*. Mr Thorley's improved hive is of this class, and Mr Lombard's *ruche villageoise* may also be referred to the same head, although it be of much simpler construction than any other compound hive. Mr Lombard's hive is composed of two parts, a body and a cover, forming together an elevation of from seventeen to twenty inches, on a uniform diameter of one foot, excepting the upper part, which ought to be convex. The body is formed of bands of straw, similar to that of the cottages in this country.

Hives of other apiarians.

Apiary. At the top and bottom of the body is placed an exterior band, which forms a projecting border on each end, the lower one giving the hive a firm station on its pedestal, the upper one contributing to secure the attachment of the cover, or allowing of another similar body being placed above the first, if such an addition should be deemed necessary. At the top of the body, and even with the upper band, is placed a flooring board, made of a light plank, ten inches in breadth in all directions, and the four corners of which are sawed off in such a manner that the breadth along the diagonal measures one foot. This board is fixed by nails inserted in the upper double band, and entering a little into the front. The four openings that are left on the sides are necessary for the passage of the bees, and for the escape of the vapours which are exhaled from them in winter. A flat rod traverses the hive immediately under the board, and projecting from the two sides about an inch and a half, affords handles for lifting the hive, and facilitates the fastening of the cover, which has also a projecting rod corresponding with that of the hive. At the bottom is an opening two inches broad and nine lines in height for the ingress and egress of the bees. The cover is formed in the shape of a dome, with a vertical handle at the top, and a cross bar at the lower part, by the projecting ends of which it may be tied to the ends of the bar in the body, and which serves also as a support to the combs that are constructed in the cover. For the latter purpose, also, two other bars are placed crosswise, one above the other. All the hives and all the bases of the covers are to be made of one uniform diameter, in order that the hives may, if occasion require it, be placed upon each other, and the covers be adapted to any of the hives that may happen to be at the top.

The *pyramidal hive* of M. Ducouédie, which the inventor extols in his book entitled *La Ruche Pyramidale, avec l'art d'établir et d'utiliser les ruches*, &c. as leaving nothing more to be wished for as to the cultivation of bees, differs but little from that of Mr Thorley. A common straw hive is taken, containing a swarm, which is allowed to remain till the spring of the following year; it is then placed on the top of a square box, with which it is made to communicate by a round aperture at the top of the box. In this state it is termed by the French *la ruche Ecossaise*, or, *ruche de M. de la Bourdonnaye*. In the following spring a second box is placed under the first, and the whole now assumes the name of *la ruche pyramidale*. The bees are still allowed no other ingress or egress but by a single hole made in the lowest story. The upper stories may then be removed in succession, while further room is allowed below by the addition of fresh boxes. It is stated by M. Ducouédie, that the bees in his pyramidal hive never perish by hunger or by cold; for they always abound in provisions, and are too numerous to be affected by the most rigorous winter. When the bees are in groups, they maintain the necessary warmth in the hive, and the brood, on the return of spring, is hatched one month sooner than in any other hive. Mr Huish has, however, made it clearly appear that these pretended advantages are much exaggerated, while its inconveniences are passed over in silence. It is difficult, if not impossible, to proportion the hives in all cases to the magnitude of the swarms, or to the energy with which they labour. The honey being taken from the oldest cells, is deteriorated by an admixture of pollen, communicating to it a degree of bitterness, of which it is difficult to deprive it; and it is less abundant, in consequence of the diminished capacity of the cells, in which the cocoons of successive bees in their state of nympha have accumulated. From their being divided into different stories, the bees are obliged to live, as it were, in different families; while their own preservation and that of the brood requires them to live in the strictest union. The heat is also lessened by the division of the bees into different groups. The upper part of these hives being all necessarily flat (except the first or straw hive), occasions a serious inconvenience, by allowing moisture to collect and drop down into the middle of the hive, instead of trickling down the sides. The injury which this does to the combs, and to the bees themselves, who are constantly exposed to its influence, is, according to Mr Huish, the most common cause of the loss of the hives during the winter. The bees, he observes, always begin their work in the most elevated point of the hive, and seek for that purpose the central part of the roof. If the top be flat, and especially if it be as spacious as in the hives called pyramidal, the bees will not find this centre; they will work one year in one part, and the following year in another. This is without doubt one of the causes which oblige a proprietor to wait three or four years before any honey can be gathered from these hives.

The hive recommended by Mr Huish as affording sufficient facility for examining any of the combs, and performing on them any operation at pleasure, is very similar in form to that described as being used in Greece. The body of the hive is a straw basket in the shape of a flower-pot, that is, of a broader diameter above than below. Eight pieces of well-seasoned wood, about eight inches broad and half an inch thick, are laid parallel to one another, at equal distances, over the top of the basket, and fastened to an outer projecting band: they are then covered with network, over which is placed a circular board, or what is better, a convex cover of straw extending over the whole of the top of the hive. This network obliges the bees to fasten their combs to the transverse boards, by means of which each comb can easily be lifted up without interfering with any other part of the hive, or occasioning the loss of a single bee; and the whole of the interior of the hive is thus open to inspection, and we are enabled to trace the devastations of the moth, or to ascertain the presence of any other enemy.—See the article Bee. (Y.)

APICIUS. There were at Rome three persons of that name, all famous for their gluttony. The second is the most celebrated of the three. He lived under Tiberius, and invented divers sorts of cakes which bore his name. He kept as it were a school of gluttony at Rome.

APINGADAM, a circle in the province of Groningen, in the kingdom of the Netherlands, comprehending four cantons, and containing 40,741 inhabitants. The chief town of the circle bears the same name, is situated on the river Fivel or Damster Diep, and contains 2660 inhabitants.

APIS, a divinity worshipped by the ancient Egyptians at Memphis, namely, an ox, having certain exterior marks. The soul of Osiris was supposed to subsist in the body of this animal. "A white spot," says Pliny, "resembling a crescent, on the right side, and a lump under the tongue, were the distinguishing marks of Apis." When a cow, therefore, which was thought to be struck with the rays of the moon, produced a calf, the sacred guides went to examine it, and if they found it conformable to this description, they announced to the people the birth of Apis.

"Immediately," says Ælian, "they built a temple to the new god, facing the rising sun, according to the precepts of Mercury, where they nourished him with milk for four months. At the expiration of this term, the priests repaired in pomp to his habitation, and saluted him by the name of Apis. They then placed him in a vessel magnificently decorated, covered with rich tapestry, and resplendent with gold and conducted him to Nilopolis, singing hymns,

and burning perfumes. There they kept him for forty days. During this space of time women alone had permission to see him, and saluted him in a particular manner. After the inauguration of the god in this city, he was conveyed to Memphis with the same retinue, followed by an innumerable quantity of boats sumptuously decked out. There they completed the ceremonies of his inauguration, and he became sacred to all the world. Apis was superbly lodged, and the place where he lay was mystically called *the bed*."

There was a mysterious term fixed for his life. "Apis," says Pliny, "cannot live beyond a certain number of years. When he has attained that period they drown him in the fountain of the priests; for it is not permitted to let him prolong his life beyond the period prescribed for him by the sacred books." When this event happened he was embalmed, and privately let down into the subterraneous place destined for that purpose, after which the priests announced that he had disappeared; but when he died a natural death before this period arrived, they proclaimed his death, and solemnly conveyed his body to the temple of Serapis. Huet, bishop of Avranches, has endeavoured to prove that Apis was a symbolical image of the patriarch Joseph, and has supported his opinion with all his erudition. Mr Bryant apprehends that the name *Apis* was an Egyptian term for father; that it referred to the patriarch Noah; and that the crescent which was usually marked on the side of the animal was a representation of the ark.

APOBATERION, in *Antiquity*, a valedictory speech or poem, made by a person on departing out of his own country, and addressed to his friends or relations.

APOCALYPSE, Revelation, the name of one of the sacred books of the New Testament, containing revelations concerning several important doctrines of Christianity. The word is Greek, and derived from αποκαλυπτω, *I reveal* or *discover*.

This book, according to Irenæus, was written about the year 96 of Christ, in the island of Patmos, whither St John had been banished by the emperor Domitian. But Sir Isaac Newton places the writing of it earlier, viz. in the time of Nero. Some attribute this book to the archheretic Cerinthus; but the ancients unanimously ascribed it to John, the son of Zebedee, and brother of James, whom the Greek fathers called the *Divine*, by way of eminence, to distinguish him from the other evangelists. This book has not at all times been esteemed canonical. There were many churches in Greece, as St. Jerome informs us, which did not receive it; neither is it in the catalogue of canonical books prepared by the council of Laodicea, nor in that of St Cyril of Jerusalem: but Justin, Irenæus, Origen, Cyprian, Clemens of Alexandria, Tertullian, and all the fathers of the fourth, fifth, and the following centuries, quote the Revelation as a book then acknowledged to be canonical. The Alogians, Marcionites, Cerdonians, and Luther himself, rejected this book: but the Protestants have forsaken Luther in this particular; and Beza has strongly maintained, against his objections, that the Apocalypse is authentic and canonical.

There have been several other works published under the title of *Apocalypses*. Sozomen mentions a book used in the churches of Palestine, called the *Apocalypse* or *Revelation of St Peter*. He also mentions an Apocalypse of St Paul, which the Cophtæ retain to this day. Eusebius also speaks of both these Apocalypses. St Epiphanius mentions an Apocalypse of Adam; Nicephorus, an Apocalypse of Esdras; Gratian and Cedrenus, an Apocalypse of Moses, another of St Thomas, and another of St Stephen; St Jerome, an Apocalypse of Elias. Porphyry, in his life of Plotin, makes mention of the Apocalypse or Revelations of Zoroaster, Zostrian, Nicothæus, Allogenes, &c.

APOCOPE, among grammarians, a figure which cuts off a letter or syllable from the end of a word; as *ingenî* for *ingenii*.

APOCRISARIUS, in *Ecclesiastical History*, a sort of resident in an imperial city, in the name of a foreign church or bishop, whose office was to negotiate, as proctor at the emperor's court, in all ecclesiastical causes in which his principals might be concerned. The institution of the office seems to have taken place in the time of Constantine, or not long after, when, the emperors having become Christians, foreign churches had more occasion to promote their suits at court than formerly. However, we find it established by law in the time of Justinian. In imitation of this officer, almost every monastery had its Apocrisarius, or resident, in the imperial city. The title and quality of apocrisary became at length appropriated to the pope's agent, or *nuncio* as he is now called, who resided at Constantinople to receive the pope's dispatches and the emperor's answers. The word is formed from αποκρινειν, *to answer*.

APOCRUSTICS, in *Medicine*, the same with repellents.

APOCRYPHA, or Apocryphal Books, such books as are not admitted into the canon of Scripture, being either not acknowledged as divine, or considered as spurious. The word is Greek, and derived from απο, and κρυπτω, *I hide* or *conceal*. When the Jews published their sacred books, they gave the appellations of *canonical* and *divine* only to those which were then made public, while such as still remained in their archives were denominated *apocryphal*, for no other reason but because they were not published; so that these books might be really sacred and divine, though not promulgated as such. Thus, in respect of the Bible, all books were called *apocryphal* which were not inserted in the Jewish canon of Scripture. Vossius observes, that, with regard to the sacred books, none are to be accounted apocryphal except such as had been admitted neither into the synagogue nor the church.

The Protestants not only consider those books apocryphal which are esteemed as such in the church of Rome—namely, the Prayer of Manasseh king of Judah, the third and fourth books of Esdras, St Barnabas's epistle, the Book of Hermos, the addition at the end of Job, and the 151st Psalm—but also Tobit, Judith, Esther, the Book of Wisdom, Jesus the Son of Sirach, Baruch the Prophet, the Song of the Three Children, the Story of Susanna, the History of Bel and the Dragon, and the books of the Maccabees. The protestant doctrine is, that these books were not received by the Jews, nor so much as known to that people. None of the writers of the New Testament cite or make mention of them; and neither Philo nor Josephus speaks of or alludes to them. The Christian church was for several ages an utter stranger to these books; while Origen, Athanasius, Hilary, Cyril of Jerusalem, and all the orthodox writers who have given catalogues of the canonical books of Scripture, unanimously concur in rejecting these from the canon. Nay, even in regard to the New Testament, these fathers are divided in opinion whether the epistle to the Hebrews, the epistle of St James, and the second epistle of St Peter, the second and third epistles of St John, the epistle of St Jude, and the Revelation, ought to be acknowledged as canonical or not. Protestants, however, acknowledge those books of Scripture only to be canonical which were accounted so in the first ages of the church,—which were cited by the earliest writers among the Christians as of divine authority, and, after the most diligent inquiry, received as such by the council of Laodicea. The several epistles above mentioned, and the book of Revelation, whatever may

have been the sentiments of particular persons respecting them, are allowed by all the reformed churches to be of divine authority, and are therefore held as constituting part of the canon of the New Testament.

APODECTÆ, in *Antiquity*, a denomination given to ten general receivers appointed by the Athenians to receive the public revenues, taxes, debts, and the like. The apodectæ had also a power to decide all controversies arising in relation to money and taxes, except those of the most difficult nature and highest concern, which were reserved to the courts of judicature.

APODES, in a general sense, denotes things without feet. Zoologists apply the name to a fabulous sort of birds, said to be found in some of the islands of the new world, which, being entirely without feet, supported themselves on the branches of trees by their crooked bills.

APODICTICAL, among philosophers, a term importing a demonstrative proof, or systematical method of teaching.

APODYTERIUM, in the ancient baths, the apartments where persons dressed and undressed.

APOGEE, in *Astronomy*, that point in the orbit of a planet which is at the greatest distance from the earth. The apogee of the sun is that part of the earth's orbit which is at the greatest distance from the sun; and, consequently, the sun's apogee and the earth's aphelion are one and the same point.

APOLIDES, in *Antiquity*, those condemned for life to the public works, or exiled into some island, and thus divested of the privileges of Roman citizens.

APOLLINARIAN GAMES, in *Roman Antiquity*, were instituted in the year of Rome 542. The occasion was a kind of oracle delivered by the prophet Marcus after the fatal battle at Cannæ, declaring that, to expel the enemy, and cure the people of an infectious disease which then prevailed, sacred games were to be annually performed in honour of Apollo; the pretor to have the direction of them, and the decemviri to offer sacrifices after the Grecian rite. The first pretor by whom they were held was P. Cornelius Sylla. For some time they were movable or indictive, but at length were fixed, under P. Licinius Varus, to the fifth of July, and made perpetual. The Apollinarian games were merely scenical, and at first only observed with singing, piping, and other sorts of music; but afterwards there were also introduced all manner of mountebank tricks, dances, and the like; yet they still remained scenical, no chariot races, wrestling, or laborious exercises of the body, being ever practised at them.

APOLLINARIANS, APOLLINARISTS, called also by Epiphanius *Dimaritæ*, ancient heretics, who denied the proper humanity of Christ, and maintained that the body which he assumed was endowed with a sensitive, and not a rational soul, but that the divine nature supplied the place of the intellectual principle in man. This sect derived its name from Apollinaris, bishop of Laodicea in the fourth century.

The Apollinarians have been charged with other opinions, such as the Millenarian and Sabellian, the pre-existence of the body of Christ, and the passion of his deity; but ecclesiastical writers are not agreed with respect to these and other particulars. Their doctrine was first condemned by a council of Alexandria in the year 362, and afterwards in a more formal manner by a council at Rome in 375, and by another council in 378, which deposed Apollinaris from his bishopric. Notwithstanding all this, his doctrine spread through most of the churches of the East, and his followers were subdivided into various sects. In 388 the emperor Theodosius enacted a law forbidding them to hold assemblies, to have any ecclesiastics or bishops, or to dwell in cities. The rigorous execution of this law, in concurrence with the decrees of different councils, reduced them to a very small number, and their doctrine had no long duration.

APOLLINARIS, CAIUS SULPICIUS, a very learned grammarian, born at Carthage, lived in the 2d century, under the Antonines. He is supposed to be the author of the verses which are prefixed to the comedies of Terence, and which contain the arguments of them. He had for his successor in the profession of grammar Helvius Pertinax, who had been his scholar, and was at last emperor.

APOLLINARIS SIDONIUS, *Caius Lollius*, an eminent Christian writer and bishop in the 5th century, was born of a noble family in France. He was educated under the best masters, and made great progress in the several arts and sciences, but particularly in poetry and polite literature. He married Papianilla, the daughter of Avitus, who was consul, and afterwards emperor, by whom he had three children. But Majorianus, in the year 475, having deprived Avitus of the empire, and taken the city of Lyons, in which our author resided, Apollinaris fell into the hands of the enemy. However, the reputation of his learning softened Majorianus's resentment, so that he treated him with the utmost civility; in return for which Apollinaris composed a panegyric in his honour, which was so highly applauded, that he had a statue erected to him at Rome, and was honoured with the title of *Count*. In the year 467 the emperor Anthemius rewarded him for the panegyric which he had written in honour of him, by raising him to the post of governor of Rome, and afterwards to the dignity of a patrician and senator. But he soon quitted these secular employments for the service of the church. The bishopric of Clermont being vacant in 472 by the death of Eparchus, Apollinaris, who was then only a layman, was chosen to succeed him. Clermont being besieged by the Goths, he animated the people to the defence of that city, and would never consent to the surrender of it; so that, when it was taken about the year 480, he was obliged to retire; but he was soon restored by Evariges, king of the Goths, and continued to govern the church as he had done before. He died on the 21st of August 487. He is esteemed one of the most elegant writers of his age, both in prose and verse. His chief works are his *Panegyrics* upon the emperors Avitus, Majorianus, and Anthemius, and a collection of *Letters* and *Poems*. The best edition of these productions is that by Sirmond, published in 1614, and republished by Labbe in 1652, in 4to. There is a French translation of his *Letters*.

APOLLO, in *Mythology*, a pagan deity worshipped by the Greeks and Romans. Cicero mentions four of this name, the most ancient of whom was the son of Vulcan; the second a son of Corybas, and born in Crete; the third an Arcadian, called Nomian, from his being a great legislator; and the last, to whom the greatest honour is ascribed, the son of Jupiter and Latona.

Apollo had a variety of other names, either derived from his principal attributes, or the chief places where he was worshipped. He was called the *Healer*, from his enlivening warmth and cheering influence; *Nomius*, or the shepherd, from his fertilizing the earth, and thence sustaining the animal creation; *Delius*, from his rendering all things manifest; *Pythius*, from his victory over Python; *Lycias*, *Phœbus*, and *Phaneta*, from his purity and splendour. As Apollo is almost always confounded by the Greeks with the sun, it is no wonder that he should be dignified with so many attributes. It was natural for the most glorious object in nature, whose influence is felt by all creation, and seen by every animated part of it, to be adored as the fountain of light, heat, and life. The power of healing diseases being chiefly given by the ancients to medicinal plants and vegetable productions, it

was natural to exalt into a divinity the visible cause of their growth. Hence he was also styled the *God of Physic;* and that external heat which cheers and invigorates all nature, being transferred from the human body to the mind, gave rise to the idea of all mental effervescence coming from this god: hence likewise, poets, prophets, and musicians, are said to be *Numine afflati*, inspired by Apollo.

Whether Apollo was a real personage, or only the great luminary, many have doubted. Vossius has taken great pains to prove this god to be only a metaphorical being, and that there never was any other Apollo than the sun. "He was styled the *Son of Jupiter*," says this author, "because that god was reckoned by the ancients the author of the world. His mother was called *Latona*, a name which signifies *hidden*, because, before the sun was created, all things were wrapped up in the obscurity of chaos. He is always represented as beardless and youthful, because the sun never grows old or decays; and what else can his bows and arrows imply, but his piercing beams?" And he adds, that all the ceremonies which were performed to his honour had a manifest relation to the great source of light which he represented. However, though this be in general true, it appears from many passages in ancient authors, that there was some illustrious personage named *Apollo*, who, after his apotheosis, was taken for the sun; as Osiris and Orus in Egypt, whose existence cannot be called in question, were, after their death, confounded with the sun, of which they became the symbols, either from the glory and splendour of their reigns, or from a belief that their souls had taken up their residence in that luminary.

Of the four Apollos mentioned by Cicero, it appears that the last three were Greeks, and the first an Egyptian, who, according to Herodotus, was the son of Osiris and Isis, and called *Orus*. Pausanias is of the same opinion as Herodotus, and ranks Apollo among the Egyptian divinities. The testimony of Diodorus Siculus is still more express; for in speaking of Isis, after saying that she had invented the practice of physic, he adds, that she taught this art to her son Orus, named *Apollo*, who was the last of the gods that reigned in Egypt.

It is easy to trace almost all the Grecian fables and mythologies from Egypt. If the Apollo of the Greeks was said to be the son of Jupiter, it was because Orus, the Apollo of the Egyptians, had Osiris for his father, whom the Greeks confounded with Jupiter. If the Greek Apollo was reckoned the god of eloquence, music, medicine, and poetry, the reason was, that Osiris, who was the symbol of the sun among the Egyptians, as well as his son Orus, had there taught those liberal arts. If the Greek Apollo was the god and conductor of the Muses, it was because Osiris carried with him, in his expedition to the Indies, singing women and musicians. This parallel might be carried on still further; but enough has been said to prove that the true Apollo was that of Egypt.

To the other perfections of this divinity the poets have added beauty, grace, and the art of captivating the ear and the heart, no less by the sweetness of his eloquence, than by the melodious sounds of his lyre.

The defeat of the serpent Python forms a celebrated incident in the history of Apollo. The waters of Deucalion's deluge, says Ovid, which had overflowed the earth, left a slime, from whence sprung innumerable monsters; and among others the serpent Python, which made great havock in the country about Parnassus. Apollo, armed with his darts, put him to death; which, physically explained, implies, that the heat of the sun having dissipated the noxious steams, these monsters soon disappeared: or, if this fable be referred to history, the serpent was a robber, who haunting the country about Delphi, and very much infesting those who came hither to sacrifice, a prince who bore the name of Apollo, or one of the priests of that god, put him to death.

This event gave rise to the institution of the Pythian games, so frequently mentioned in the Grecian history; and it was from the legend of Apollo's victory over the Python that the god himself acquired the name of *Pythius*, and his priestess that of *Pythia*. The city of Delphi, where the famous oracles were so long delivered, was frequently styled *Pytho*.

Apollo Belvidere, ranked the first in the first class of ancient statues, and so called from having been placed in the Belvidere of the Vatican at Rome by Pope Julius II., where it remained for 300 years, and till Rome was taken and plundered by the French in 1797. This celebrated statue was found in the ruins of ancient Antium about the end of the 15th century. The artist is unknown.

APOLLODORUS, a famous architect under Trajan and Adrian, was born at Damascus. He had the direction of the bridge of stone which Trajan ordered to be built over the Danube in the year 104, which was esteemed the most magnificent of all the works of that emperor. Adrian, one day as Trajan was discoursing with this architect upon the buildings he had raised at Rome, would needs give his judgment, and showed he understood nothing of the matter. Apollodorus turned upon him bluntly, and said to him, "Go paint gourds, for you are very ignorant of the subject we are talking upon." Adrian at this time boasted of his painting gourds well. The insult cost Apollodorus his life.

Apollodorus, a celebrated painter of Athens about 408 years before the birth of Christ, was the first who invented the art of mingling colours, and of expressing lights and shades. He was admired also for his judicious choice of subjects, and for beauty and strength of colouring surpassed all the masters that went before him. He excelled likewise in statuary.

Apollodorus the Athenian, a famous grammarian, the son of Asclepiades and disciple of Aristarchus. He wrote many works not now extant; but his most famous production is his *Bibliotheca*, which treats of the gods and the heroic ages. It is supposed by some that this is only an abridgement by another hand, and not the original work of Apollodorus. In any view it is, however, of value in mythological inquiries. The best edition is that of Heyne, in 2 vols. 8vo, published in 1803. A French translation, with notes, was published at Paris in 1805, in 2 vols. 8vo.

APOLLONIUS of Perga, in Pamphylia, is one of the most illustrious of the ancient Greek geometricians. The date of his birth has not been precisely ascertained; but as he flourished under Ptolemy Philopater, who died in the year 205 B.C., after a reign of 16 years, it is conjectured that he was born about the middle of the third century before our era, and that he was about 40 years posterior to Archimedes. He studied at Alexandria under the successors of Euclid, and is pre-eminently distinguished among the disciples of that illustrious school, in which the mathematical sciences were at all times held in the highest estimation.

Few of the numerous compositions of Apollonius have escaped the ravages of time; but the description which has been given of them by Pappus, in the preface to the seventh book of the *Mathematical Collections*, explains their nature and value, and gives the admirers of the ancient analysis great reason to regret the loss of those which have perished. The most celebrated of his productions was the treatise on the *Conic Sections;* a work which, according to the testimony of Geminius Rhodius, was regarded with so much admiration by the contemporaries of

Apollonius. its author, that they bestowed on him the title of the *Great Geometrician.* This title is justified by the excellence of the work, which is unquestionably far superior to any treatise on the subject which we know to have existed among the ancients, and which has not indeed, in some respects, been surpassed in modern times. But while we bestow this praise on the treatise of Apollonius, we are not to suppose that he was the inventor of all, or even the greater part, of the properties which are demonstrated in it. Several treatises on the conic sections are known to have existed previously, in which the theory of these curves seems to have been prosecuted to a very considerable length. Pappus mentions, in particular, in terms of the highest eulogy, the five books on Solid Loci, or the conic sections, which were composed by Aristæus *the ancient,* who lived about 350 years B. C.; and the construction given by Menechmus, of the problem to find two mean proportionals between two given straight lines, which leads to the duplication of the cube, shows that the disciples of Plato had advanced far in the same department of geometry. In fact, as it was the object of Apollonius to give a complete treatise of the conic sections, he did not scruple to avail himself of the discoveries of his predecessors, and, accordingly, embodied in his own work what had previously been done by Aristæus, Eudoxus of Cnidus, Menechmus, Euclid, Conon, Thrasidæus, Nicoteles, and others. It is now impossible to distinguish the propositions which were borrowed from his predecessors from those which were invented by himself; but it is certain that he both made great additions to the theory of the conic sections, and improvements in the manner of treating it. Eutocius informs us that Apollonius was the first who showed that all the three sections may be cut from the same cone, by varying the position of the intersecting plane; for previous authors had always supposed the plane of the section perpendicular to the side of the cone,—an hypothesis which requires that the three sections be cut from three cones of different species, namely, the parabola from a right-angled cone, the ellipse from an obtuse, and the hyperbola from an acute. It has, however, been established by Guido Ubaldus, in his commentary on the second book of the *Æquiponderantes* of Archimedes, that the Syracusan geometer was acquainted with the fact, that the three sections may be derived from the same cone. The generalization is indeed so very obvious, that we can scarcely persuade ourselves that it was not previously made by the more ancient writers; and it is probable, that if they usually assumed the cutting plane to have a particular position with reference to the cone, it was only on account of some facilities which that hypothesis afforded them in establishing the fundamental properties of the sections. Pappus ascribes to Apollonius the names by which the three sections are now distinguished and characterized: the term *Parabola,* however, occurs in the writings of Archimedes.

Of the eight books which Apollonius composed on the conic sections, the first four only have reached us in the original Greek. Three more have been preserved through the medium of an Arabic version; the last is unfortunately lost. A Latin translation of the first four was published by Memmius, at Venice, in 1537; and another, much more accurate, by Commandine, in 1568, with the addition of the commentary of Eutocius, and the lemmas of Pappus to all the eight books. Hitherto the last four books had not been discovered; but as the nature of their contents was sufficiently known from the indications of Pappus, several attempts were made to supply their loss by a restoration. Maurolycus, a Sicilian geometer of the 16th century, successfully commenced the theory of the fifth and sixth books; and Viviani, the last and favourite disciple of the illustrious Galileo, was employed on the same subject, when two different manuscript versions of the work of Apollonius were accidentally brought to light. Among a number of Arabic manuscripts brought from the East by Golius, one was found which contained seven books of the conics. Golius was sufficiently instructed in geometry to be aware of the value of his discovery; he hastened to communicate it to the mathematicians of that time, and proposed to publish a translation of the work. This project, however, failed from some cause which has not been explained; and, notwithstanding the intimation which had been given, the last four books still continued to be regarded as lost, till the year 1658, when Alphonso Borelli, the celebrated author of the treatise *De Motu Animalium,* happened to discover, in the library of the Medici at Florence, an Arabic manuscript with the following inscription: *Apollonii Pergæi Conicorum Libri Octo.* Borelli obtained permission to carry this manuscript to Rome, where, with the assistance of Abraham Ecchellensis, he translated the fifth, sixth, and seventh books. Notwithstanding the inscription, the eighth book was wanting; and as this was also the case with regard to the manuscript of Golius, it seems probable that it had not been translated into Arabic.

The last four books of the conics of Apollonius formed a considerable part of what may be termed the transcendental geometry of the ancients; and they exhibit some of the most elegant and successful applications of the geometrical analysis. The fifth book, for example, which treats of the greatest and least lines that can be drawn from given points to the peripheries of the curves, contains nearly all the properties of normals and radii of curvature which are now generally investigated by the aid of the differential calculus, and almost anticipates the admirable theory of involutes and evolutes which confers so brilliant a lustre on the name of Huygens. The seventh book also contains some theorems which, although they have now passed into the elements, are sufficiently difficult and remote to afford scope for the exercise of address and ingenuity, even when their investigation is attempted by the modern analysis. Dr Halley, guided by the description of Pappus, divined the contents of the eighth book, and published a magnificent edition of the whole at Oxford in 1710.

The other treatises of Apollonius which are mentioned by Pappus are the following:—1*st,* The Section of Ratio, or Proportional Sections; 2*d,* the Section of Space; 3*d,* the Determinate Sections; 4*th,* the Tangencies; 5*th,* the Inclinations; 6*th,* the Plane Loci. Each of these was divided into two books, and, with the *data* of Euclid and the *porisms,* they formed the eight treatises which, according to Pappus, constituted the body of the ancient analysis. Of the above treatises of Apollonius, the first only has reached us through an Arabic translation. It was discovered in Arabic among the Selden manuscripts in the Bodleian Library at Oxford, by Dr Edward Bernard, who commenced a translation of it, from which, however, he was deterred by the difficulties occasioned by the extreme inaccuracy of the manuscript before he had finished a tenth part. This small portion of the translation was revised by Dr David Gregory; the rest was translated, or more properly speaking, divined, by Dr Halley, who published it in 1706, together with the analogous treatise on the *Section of Space,* which he had restored after the indication of its contents given by Pappus. The general problem resolved in the first treatise, although it is branched out into a great variety of cases, may be comprehended in the following enunciation: "Two straight lines being given by position, together with a point in each, it is required to draw through a third given point a straight

line intersecting the two former straight lines, so that the segments intercepted between the given points and the points of intersection with the third line may be to each other in a given ratio." The problem which forms the subject of the second treatise differs from the above only in requiring that the intercepted segments on the two straight lines given by position shall contain a given rectangle.

The object of the treatise on the *Determinate Sections* was "to find a point in a straight line given by position, the rectangles or squares of whose distances from given points in the given straight line shall have a given ratio." A restoration of this and the two preceding treatises was attempted by Snellius; but although he certainly resolved the problems which had been proposed by Apollonius, his solutions were far inferior in point of elegance to those of the Greek geometer. The discovery of the treatise on the Section of Ratio enabled a comparison to be made of the restored with the original work. Some cases of the *Determinate Section* were also resolved by Alexander Anderson of Aberdeen, in his supplement to the *Apollonius Redivivus*, published at Paris in 1612. But by far the most complete and elegant restoration of the problem was given by Dr Simson of Glasgow, with two additional books on the same subject. It has been published among his posthumous works.

The treatise on *Inclinations*,—the object of which was to insert a straight line of a given length, and tending to a given point, between two lines (straight lines or circles) given by position,—was first investigated by Marinus Ghetaldus, a patrician of Ragusa, afterwards by Hugo de Omerique in his ingenious treatise on the *Geometrical Analysis*, published at Cadiz in 1698. The different cases of the problem have been resolved in a very elegant manner by Dr Horsley, who published his restoration in 1770.

The treatise *de Tactionibus*, which relates to the contact of circles and straight lines, has afforded exercise for the ingenuity of many modern mathematicians. The general problem which it embraces may be enunciated as follows: Three things (points, straight lines, or circles) being given by position, it is required to describe a circle which may pass through the given points and touch the given straight lines and circles. The most difficult case of the problem is that in which the three things given are circles; the question being then to determine the centre and radius of a circle, which shall touch these circles given in magnitude and position. This problem, which is now considered as quite elementary, possesses an historical interest on account of the great names connected with its solution. It was proposed by Vieta, the most skilful geometrician of the 16th century, to Adrianus Romanus, who, in constructing it, employed the very obvious consideration of the intersection of two hyperbolas. Such a solution of a plane problem, which ought to be constructed by means of straight lines and circles only, was very far from being satisfactory to Vieta: he therefore himself proposed a more geometrical construction, and restored the whole treatise of Apollonius, in a small work which he published at Paris in 1660 under the title of *Apollonius Gallus*. The treatise of Vieta is entitled to the praise of great ingenuity, but it falls far short of the geometrical elegance of the known productions of Apollonius; and simpler solutions have since been found of the more difficult cases of the general problem. An algebraic solution of the same question was attempted by Descartes; but the equations at which he arrived were so exceedingly complicated, that he himself ingenuously confessed that he should not be able to construct one of them in a shorter time than three months. The Princess Elizabeth of Bohemia, who carried on an epistolary correspondence with Descartes, gave a solution of the same kind. Newton himself, in his *Universal Arithmetic*, condescended to consider this problem; but he succeeded little better than Vieta, whose method he followed. In the 16th lemma of the first book of the *Principia*, he has, however, given a different and simpler investigation, and reduced with great skill the two hyperbolic loci of Adrianus Romanus to the intersection of two straight lines. Simple geometrical solutions, since that of Dr Simson was published, are to be found in every elementary work. In speaking of this problem, Montucla observes, that it is one of those to which the algebraic analysis applies with difficulty. His opinion, however, would have been different had he lived to see the extremely simple and elegant algebraic investigation given by Gergonne in the *Annales des Mathématiques*, not only of this, but of the analogous problem in space which was proposed by Descartes to Fermat, viz. to describe a sphere touching four spheres given by position. In fact, it would be difficult to select a problem in elementary geometry better calculated to display the resources and pliability of the algebraic calculus, than this very one which had been considered as belonging so exclusively to the analysis of the ancients. A very full and interesting historical account of this problem is given in the preface to a little work of Camerer, entitled *Apollonii Pergæi quæ supersunt, ac maxime Lemmata Pappi in hos libros, cum Observationibus*, &c. Gothæ, 1795, 8vo.

The last of the treatises mentioned by Pappus,—*de Locis Planis*,—is only a collection of properties of the straight line and circle, and corresponds to the construction of equations of the first and second degree. It has been restored in the true spirit of the ancient geometry by Dr Simson, whose treatise well deserves the attention of the student.

Besides the works which we have now enumerated, we are informed, by the fragment of the second book of Pappus, published among the works of Dr Wallis, that Apollonius occupied himself with arithmetical researches, and composed a treatise on the multiplication of large numbers. Astronomy is also indebted to him for the discovery, or at least for the demonstration, of the method of representing, by means of epicycles and deferents, the phenomena of the stations and retrogradations of the planets. He appears also to have been the inventor of the method of projections, and has the distinguished merit of having been the first who attempted to found astronomy on the principles of geometry, and establish an alliance between these two sciences which has been productive of the greatest benefit to both.

Of the personal character of this most assiduous and inventive geometrician, nothing is known excepting what may be gathered from a few unfavourable hints thrown out by Pappus. Pappus describes him as vain, arrogant, envious of the reputation of others, and inclined to depreciate their merit; and contrasts him with the amiable and disinterested Euclid, who was always ready to allow to every one his just share of praise, and who manifested on every occasion the most benevolent feelings towards all men, especially towards those who laboured to improve or extend the science of geometry. The charge of appropriating to himself the discoveries of Archimedes, which was brought against Apollonius by Heraclius, had probably no other foundation than the boastful manner in which he spoke of his own discoveries, and affected to despise those of other mathematicians; for, as has been well remarked, pretensions pushed too far excite in the rest of mankind a sort of re-action of self-love, which leads them to contest the most legitimate titles. But whatever may have been the case with regard to the per-

Apollonius. sonal qualities of Apollonius, the powers of his mind and his unwearied industry command universal admiration. The great value attached to his productions by the ancients is manifest from the number and celebrity of the commentators who undertook to explain them. Among these we find the names of Pappus, the learned and unfortunate Hypatia, Serenus, Eutocius, &c.

The remarkable editions of the works of Apollonius are the following:—1. *Apollonii Pergæi Conicorum libri quatuor, ex versione Frederici Commandini.* Bononiæ, 1566, fol. 2. *Apollonii Pergæi Conicorum libri* v. vi. vii. *Paraphraste Abalphato Asphanensi nunc primum editi: Additus in calce Archimedis Assumtorum liber, ex Codicibus Arabicis Manuscr.: Abrahamus Ecchellensis Latinos reddidit: J. Alfonsus Borellus curam in Geometricis Versioni contulit, et Notas uberiores in universum opus adjecit.* Florentiæ, 1661, fol. 3. *Apollonii Pergæi Conicorum libri octo, et Sereni Antissensis de Sectione Cylindri et Coni libri duo.* Oxoniæ, 1710, fol. (This is the splendid edition of Dr Halley.) 4. The edition of the first four books of the Conics given in 1675 by Barrow. 5. *Apollonii Pergæi de Sectione Rationis libri duo: Accedunt ejusdem de Sectione Spatii libri duo Restituti: Præmittitur, &c. Opera et Studio Edmundi Halley.* Oxoniæ, 1706, 4to.

See Bayle's *Dictionary;* Bossut, *Essai sur l'Hist. Gén. des Math.*, tome i.; Montucla, *Hist. des Math.*, tome i.; Vossius *de Scient. Math.;* Simson's *Sectiones Conicæ*, preface; and Hutton's *Mathematical Dictionary.* (s.)

Apollonius, the author of the *Argonautics*, and surnamed the Rhodian, from the place of his residence, is supposed to have been a native of Alexandria, where he is said to have recited some portion of his poem while he was yet a youth. Finding it ill received by his countrymen, he retired to Rhodes, where he is conjectured to have polished and completed his work, supporting himself by the profession of rhetoric, and receiving from the Rhodians the freedom of their city. He at length returned with considerable honour to the place of his birth, succeeding Eratosthenes in the care of the Alexandrian library in the reign of Ptolemy Euergetes, who ascended the throne of Egypt in the year before Christ 246. That prince had been educated by the famous Aristarchus, and rivalled the preceding sovereigns of his liberal family in the munificent encouragement of learning. Apollonius was a disciple of the poet Callimachus; but their connection ended in the most violent enmity, which was probably owing to some degree of contempt expressed by Apollonius for the light compositions of his master. The learned have vainly endeavoured to discover the particulars of their quarrel. The only work of Apollonius which has descended to modern times is his poem above mentioned, in four books, on the Argonautic expedition. Both Longinus and Quintilian have assigned to this work the mortifying character of mediocrity. It was published for the first time at Florence in 1496, with the ancient Greek Scholia, in a 4to volume, now exceedingly rare. There is an excellent edition by Brunck, published in 1780, and another by Beck, published in 1797; but the best is that of Professor Schäfer, printed at Leipsic in 2 vols. 8vo, in 1810–13.

Apollonius, a Pythagorean philosopher, born at Tyana in Cappadocia about the beginning of the first century. At 16 years of age he became a strict observer of Pythagoras's rules, renouncing wine and all sorts of flesh; not wearing shoes, letting his hair grow, and wearing nothing but linen. He soon after set up for a reformer of mankind, and chose his habitation in a temple of Æsculapius, where he is said to have performed many wonderful cures. Philostratus has written the life of Apollonius, in which there are numberless fabulous stories recounted of him. We are told that he went five years without speaking, and yet during that time stopped many seditions in Cilicia and Pamphylia; that he travelled, and set up for a legislator; that he gave out he understood all languages without having ever learned them; and that he could tell the thoughts of men, and understood the oracles which birds gave by their singing. The heathens were fond of opposing the pretended miracles of this man to those of our Saviour; and by a treatise which Eusebius wrote against one Hierocles, we find that the object of the latter, in the treatise which Eusebius refutes, seems to have been to draw a parallel between Jesus Christ and Apollonius, in which he gives the preference to this philosopher. M. Dupin wrote a confutation of Philostratus's life of Apollonius.

Apollonius wrote four books of Judicial Astrology; a Treatise upon the Sacrifices, showing what was proper to be offered to each deity; and a great number of Letters; all of which are now lost.

APOLLOS, in *Scripture History*, a Jew of Alexandria, who came to Ephesus during the absence of St Paul, who was gone to Jerusalem. (Acts xviii. 24.) Apollos was an eloquent man, and well versed in the Scriptures; and as he spoke with zeal and fervour, he taught diligently the things of God: but knowing only the baptism of John, he was no more than a catechumen, or one of the lowest order of Christians, and did not as yet distinctly know the mysteries of the Christian doctrine. However, he knew that Jesus Christ was the Messiah, and declared himself openly to be his disciple. When, therefore, he was come to Ephesus, he began to speak boldly in the synagogue, and to show that Jesus was the Christ. Aquila and Priscilla having heard him, took him home with them, instructed him more fully in the ways of God, and baptized him, probably in the name of Jesus Christ.

Some time after this he had a mind to go into Achaia; and the brethren having exhorted him to undertake this journey, they wrote to the disciples, desiring them to receive him. He arrived at Corinth, and was there very useful in convincing the Jews out of the Scriptures, and demonstrating to them that Jesus was the Christ. Thus he watered what St Paul had planted in this city. (1 Cor. iii. 6.) But the great affection which his disciples entertained for him threatened to produce a schism, some saying I am of Paul, others I am of Apollos, I am of Cephas. However, this division, which St Paul speaks of in the chapter last quoted, did not prevent that apostle and Apollos from being closely united by the bonds of charity. Apollos hearing that the apostle was at Ephesus, went to meet him, and was there when St Paul wrote the first epistle to the Corinthians; wherein he testifies that he had earnestly entreated Apollos to return to Corinth, but hitherto had not been able to prevail with him; that nevertheless he gave him room to hope that he would go when he had an opportunity. St Jerome says that Apollos was so dissatisfied with the division which had happened upon his account at Corinth, that he retired into Crete with Zena, a doctor of the law; and that this disturbance having been appeased by the letter which St Paul wrote to the Corinthians, Apollos returned to this city, and was bishop thereof. The Greeks make him bishop of Duras, others say he was bishop of Iconium in Phrygia, and others that he was bishop of Cæsarea.

APOLLYON, a Greek word that signifies *the destroyer*, and answers to the Hebrew *Abaddon*. St John in the Revelation (ix. 11) says that an angel having opened the bottomless pit, a thick smoke issued out of it, and with this smoke locusts, like horses prepared for battle, and commanded by the angel of the bottomless pit, called in Hebrew *Abaddon*, but in Greek *Apollyon*.

APOLOGUE, in matters of literature, an ingenious method of conveying instruction by means of a feigned relation called a *moral fable*. The only difference between a parable and an apologue is, that the former, being drawn from what passes among mankind, requires probability in the narration; whereas the apologue, being taken from the supposed actions of brutes, or even of things inanimate, is not tied down to the strict rules of probability. Æsop's fables are a model of this kind of writing.

APOMYOS DEUS (απο, and μυια, *fly*), in the *Heathen Mythology*, a name under which Jupiter was worshipped at Elis, and Hercules as well as Jupiter at the Olympic games. These deities were supplicated under this name to destroy or drive away the vast number of flies which always attended at the great sacrifices; and in those which accompanied the Olympic games, the first was always to the Apomyos, or Myiagrus Deus, that he might drive away the flies from the rest. The usual sacrifice was a bull.

APONO, PETER D', one of the most famous philosophers and physicians of his age, born in the year 1250, in a village about four miles from Padua. He was suspected of magic, and prosecuted by the inquisition. "The common opinion of almost all authors," says Naudé, "is, that he was the greatest magician of his age; that he had acquired the knowledge of the seven liberal arts by means of the seven familiar spirits, which he kept inclosed in a crystal; and that he had the dexterity to make the money he had spent come back into his purse." The same author adds, that he died before the process against him was finished, being then in the 80th year of his age; and that, after his death, they ordered him to be burnt in effigy, in the public place of the city of Padua. He was the author of various works, the most remarkable of which are the following: *Conciliator Differentiarum Philosophorum*, first published in 1471; *De Venenis eorumque Remediis*, which was translated into French by Boet in 1593; *Expositio Problematum Aristotelis*, 1475; *Geomantia*, 1549; and *Dionocides digestus Alphabet. Ord.* 1512.

APOPEMPTIC, in ancient poetry, a hymn addressed to a stranger on his departure from a place to his own country. The ancients had certain holydays, wherein they took leave of the gods with *apopemptic* songs, as supposing them returning each to his own country. The deities having the patronage of divers places, it was but just to divide their presence, and allow some time to each. Hence it was that among the Delians and Milesians we find feasts of Apollo, and among the Argians feasts of Diana, called *Epidemiæ*, as supposing these deities then more peculiarly resident among them. On the last day of the feast they dismissed them, following them to the altars with *apopemptic* hymns.

APOPHTHEGM, a short, sententious, and instructive remark, pronounced by a person of distinguished character.

APOPLEXY, a distemper in which the patient is suddenly deprived of all his senses, and of voluntary motion. See MEDICINE.

APORIA, a figure in *Rhetoric*, by which the speaker shows that he doubts where to begin for the multitude of matter, or what to say in some strange and ambiguous thing, and, as it were, argues the case with himself.

APORON, or APORIME, a problem difficult to resolve, and which has never been resolved, though it be not in itself impossible. The word is derived from απορος, which signifies something very difficult and impracticable, being formed from the privative α, and πορος, *passage*. When a question was proposed to any of the Greek philosophers, especially of the sect of academists; if he could not give a solution, his answer was Απορεω, *I cannot see through it*. This word is also used by some law writers for an inexplicable speech or discourse.

APOSIOPESIS, in *Rhetoric*, afterwards called *reticency* and *suppression*, a figure by which a person really speaks of a thing, at the same time that he makes a show as if he would say nothing of it. The word comes from αποσιωπαω, *I am silent*. It is commonly used to denote the same with ellipsis.

APOSPHRAGISMA (from απο, and σφραγιζω, *I seal*), in *Antiquity*, the figure or impression of a seal. It was forbidden among the ancients to have the figure or image of God on their rings and seals. To this purpose the precept of Pythagoras, Εν δακτυλιῳ εικονα Θεου μη περιφερειν! But in process of time this was little regarded; it was usual enough to have the figures of Egyptian and other deities, as well as of heroes, monsters, friends, ancestors, and even brutes, on their *dactyli* or ring-seals.

APOSTASY, a renouncing of the true religion. The primitive Christian church distinguished several kinds of apostasy. The first, of those who went over entirely from Christianity to Judaism; the second, of those who mingled Judaism and Christianity together; and the third, of those who complied so far with the Jews as to communicate with them in many of their unlawful practices, without making a formal profession of their religion. But the fourth sort was of those who, after having been some time Christians, voluntarily relapsed into Paganism.

APOSTLE properly signifies a messenger or person sent by another upon some business; and hence, by way of eminence, denotes one of the disciples commissioned by Jesus Christ to preach the gospel.

Christ selected twelve out of the number of his disciples to be invested with the apostleship. Their names were Simon Peter, Andrew, James the greater, John, Philip, Bartholomew, Thomas, Matthew, James the less, Jude, surnamed Lebbeus or Thaddeus, Simon the Canaanite, and Judas Iscariot. Of these, Simon, Andrew, James the greater, and John, were fishermen, and Matthew a publican, or receiver of the public revenue; of what profession the rest were we are not told in Scripture, though it is probable they were fishermen.

Our Lord's first commission to his apostles was in the third year of his public ministry, about eight months after their solemn election; at which time he sent them out by two and two. They were to make no provision of money for their subsistence in their journey, but to expect it from those to whom they preached. They were to declare that the kingdom of heaven, or the Messiah, was at hand; and to confirm their doctrine by miracles. They were to avoid going either to the Gentiles or to the Samaritans, and to confine their preaching to the people of Israel. In obedience to their Master, the apostles went into all the parts of Palestine inhabited by the Jews, preaching the gospel and working miracles. The evangelical history is silent as to the particular circumstances attending this first preaching of the apostles, and only informs us that they returned and told their Master of all that they had done.

Their second commission, just before our Lord's ascension, was of a more extensive and particular nature. They were now not to confine their preaching to the Jews, but to "go and teach ALL nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost." Accordingly they began publicly, after our Lord's ascension, to exercise the office of their ministry, working miracles daily in proof of their mission, and making great numbers of converts to the Christian faith. This alarmed the Jewish Sanhedrim; whereupon the apostles were apprehended, and being examined before the high-priest and elders, were commanded not to preach any more in the name of Christ. But this injunction did not terrify them from persisting in the duty of their calling; for they

continued daily, in the temple, and in private houses, teaching, and preaching the gospel.

After the apostles had exercised their ministry for twelve years in Palestine, they resolved to disperse themselves in different parts of the world, and agreed to determine by lot what parts each should take. According to this division, St Peter went into Pontus, Galatia, and other provinces of the Lesser Asia; St Andrew had the vast northern countries of Scythia and Sogdiana allotted to his portion; St John's was partly the same with Peter's, namely, the Lesser Asia; St Philip had the Upper Asia assigned to him, with some parts of Scythia and Colchis; Arabia Felix fell to St Bartholomew's share; St Matthew preached in Chaldea, Persia, and Parthia; St Thomas preached likewise in Parthia, as also to the Hyrcanians, Bactrians, and Indians; St James the less continued in Jerusalem, of which church he was bishop; St Simon had for his portion Egypt, Cyrene, Libya, and Mauritania; St Jude, Syria and Mesopotamia; and St Matthias, who was chosen in the room of the traitor Judas, Cappadocia and Colchis. Thus, by the dispersion of the apostles, Christianity was very early planted in a great many parts of the world. We have but very short and imperfect accounts of their travels and actions.

In order to qualify the apostles for the arduous task of converting the world to the Christian religion, they were, in the first place, miraculously enabled to speak the languages of the several nations to whom they were to preach; and, in the second place, were endowed with the power of working miracles, in confirmation of the doctrines they taught; gifts which were unnecessary, and therefore ceased, in the after-ages of the church, when Christianity came to be established by the civil power.

St Paul is frequently called the *apostle* by way of eminence; and the *apostle of the Gentiles*, because his ministry was chiefly made use of for the conversion of the gentile world, as that of St Peter was for the Jews, who is therefore styled the *apostle of the circumcision*. The several apostles are usually represented with their respective badges or attributes: St Peter with the keys; St Paul with a sword; St Andrew with a cross or saltier; St James minor with a fuller's pole; St John with a cup, and a winged serpent flying from it; St Bartholomew with a knife; St Philip with a long staff, whose upper end is formed into a cross; St Thomas with a lance; St Matthew with a hatchet; St Matthias with a battle-axe; St James major with a pilgrim's staff and a gourd bottle; St Simon with a saw; and St Jude with a club.

Apostle was also used among the Jews for a kind of officer anciently sent into the several parts and provinces in their jurisdiction, by way of visitor or commissary, to see that the laws were duly observed, and to receive the monies collected for the reparation of the temple, and the tribute payable to the Romans.

Apostle, in the *Greek liturgy*, is particularly used for a book containing the epistles of St Paul, printed in the order in which they are to be read in churches through the course of the year. Another book of the like kind, containing the Gospels, is called Ευαγγελιον, *Gospel*. The Apostle, of late days, has also contained the other canonical epistles, the Acts of the Apostles, and the Revelation. Hence it is also called *Acts of the Apostles*, Πραξαποστολος; that being the first book in it.

Apostle is also thought by many to have been the original name for bishops, before the denomination *bishop* was appropriated to their order. Thus Theodoret says expressly, the same persons were anciently called promiscuously both bishops and presbyters, while those who are now called bishops were called *apostles*.

Apostles' *Creed*, a formula or summary of the Christian faith, drawn up, according to Ruffinus, by the apostles themselves, as a rule of faith, and as a *word of distinction*, by which they were to know friends from foes. Baronius and some other authors conjecture that they did not compose it till the second year of the reign of Claudius, a little before their dispersion. As to their manner of composing it, some fancy that each apostle pronounced his article, which is the reason of its being called *symbolum apostolicum;* it being made up of sentences jointly contributed, after the manner of persons paying each their club (*symbolum*) or share of a reckoning.

But there are reasons which may induce us to question whether the apostles composed any such creed as this. For, first, neither St Luke in the Acts, nor any other ecclesiastical writer before the 5th century, makes any mention of an assembly of the apostles in order to the composing of a creed. Secondly, The fathers of the first three centuries, in disputing against the heretics, endeavoured to prove that the doctrine contained in this creed was the same which the apostles taught; but they never pretend that the apostles composed it. Thirdly, If the apostles had made this creed, it would have been the same in all churches and in all ages; and all authors would have cited it after the same manner. But the case is quite otherwise. In the second and third ages of the church there were as many creeds as authors, and one and the same author sets down the creed after a different manner in several places of his works, which is an evidence that there was not at that time any creed which was reputed the production of the apostles. In the fourth century Ruffinus compares together the three ancient creeds of the churches of Aquileia, Rome, and the East, which differ very considerably in the terms. Besides, these creeds differed not only in the terms and expressions, but even in the articles, some of which were omitted in one or other of them, such as those of the *descent into hell*, the *communion of the saints*, and the *life everlasting*. From these reasons it may be gathered, that though this creed may be said to be that of the apostles in regard to the doctrines contained therein, yet it is not to be referred to them as the authors and first composers of it. Who was the true author of it, it is not easy to determine, though its great antiquity may be inferred from this, that the whole form, as it now stands in the English liturgy, is to be found in the works of St Ambrose and Ruffinus, both of whom flourished in the fourth century.

APOSTOLIC, in the primitive church, was an appellation given to all such churches as were founded by the apostles; and even to the bishops of those churches, as being the reputed successors of the apostles. These were confined to four, viz. Rome, Alexandria, Antioch, and Jerusalem. In after-times other churches assumed the same quality, on account, principally, of the conformity of their doctrine with that of the churches which were apostolical by foundation, and because all bishops held themselves successors of the apostles, or acted in their dioceses with the authority of apostles.

Apostolical *Fathers* is an appellation usually given to the writers of the first century who employed their pens in the cause of Christianity. Of these writers, Cotelerius, and after him Leclerc, have published a collection in two volumes, accompanied both with their own annotations and the remarks of other learned men.

APOSTOLIANS, a sect of the Mennonites, which first sprung up in the year 1663, and derived its name from Apostool, one of the Mennonite ministers at Amsterdam. They concurred with them in doctrine, and admitted to their communion those only who professed to believe all the sentiments which are contained in their public confession of faith.

APOSTOLICI, or Apostolics, was a name assumed by three different sects, on account of their pretending to imitate the manner and practice of the apostles. The first apostolici, otherwise called *Apotactitæ* and *Apotactici*, rose out of the Encratitæ and Cathari in the third century. They made profession of abstaining from marriage, and the use of wine, flesh, money, &c. Gerhard Sagarelli was the founder of the second sect: he obliged his followers to go from place to place as the apostles did, to wander about clothed in white, with long beards, dishevelled hair, and bare heads, accompanied with women, whom they called their spiritual sisters. They likewise renounced all kinds of property and possessions, inveighed against the growing corruption of the church of Rome, and predicted its overthrow, and the establishment of a purer church on its ruins. Sagarelli was burnt alive at Parma in the year 1300, and was afterwards succeeded by Dulcinus, who added to the character of an apostle that of a prophet and of a general, and carried on a bloody and dreadful war for the space of more than two years against Reynerius, bishop of Vercelli: he was at length defeated, and put to death in a barbarous manner, in the year 1307. Nevertheless, the sect subsisted in France, Germany, and other countries, till the beginning of the 15th century, when it was totally extirpated under the pontificate of Boniface IX. The other branch of apostolici was of the 12th century. These also condemned marriage, preferring celibacy, and calling themselves the chaste brethren and sisters; though each was allowed a spiritual sister, with whom he lived in a domestic relation; and on this account they have been charged with concubinage. They held it unlawful to take an oath, they set aside the use of baptism, and in many things imitated the Manichees. Bernard wrote against this sect of apostolici.

APOSTOLICUM is a peculiar name given to a kind of song or hymn, anciently used in churches. The apostolicum is mentioned by Greg. Thaumaturgus as used in his time. Vossius understands it as spoken of the apostles' creed: Suicer thinks this impossible, because this creed was then unknown in the churches of the East.

APOSTROPHE, in *Rhetoric*, a figure by which a person who is either absent or dead is addressed as if he were present and attentive to us. This figure is, in boldness, a degree lower than the addresses to personified objects (see Personification), since it requires a less effort of imagination to suppose persons present who are dead or absent, than to imitate insensible beings and direct our discourse to them.

Apostrophe, in *Grammar*, the contraction of a word by the use of a comma; as *call'd* for *called*, *tho'* for *though*.

APOTACTITÆ, or Apotactici, an ancient sect, who, affecting to follow the examples of the apostles and primitive Christians, renounced all their possessions, and devoted them to the common cause. It does not appear that they at first fell into any errors. Some ecclesiastical writers assure us that several holy virgins and martyrs of this sect suffered under the persecution of Dioclesian in the fourth century; but they afterwards embraced the opinions of the Encratitæ, and taught that the renouncing of all riches was not only a matter of counsel and advice, but of precept and necessity; and hence the sixth law in the Theodosian code joins the Apotactitæ with the Eunomians and Arians.

APOTEICHISMUS, in the ancient military art, a kind of line of circumvallation drawn round a place in order to besiege it. This was also called *periteichismus*. The first thing the ancients went about when they designed to lay close siege to a place, was the apoteichismus, which sometimes consisted of a double wall or rampart, raised of earth; the innermost to prevent sudden sallies from the town, the outermost to keep off foreign enemies from coming to the relief of the besieged. This answered to what are called *lines of contravallation* and *circumvallation* among the moderns.

APOTHECARY, one who practises the art of pharmacy. In London, the apothecaries are one of the city companies. They were incorporated by a charter from King James I., procured at the solicitation of Dr Mayerne and Dr Atkins: till that time they only made a part of the grocers' company; plums, sugar, spice, &c. being sold in the same shop and by the same person. By an act which was made perpetual in the ninth year of George I. they are exempted from serving upon juries, or in ward and parish offices. They are obliged to make up their medicines according to the formulas prescribed in the college dispensatory; and are liable to have their shops visited by the censors of the college, who are empowered to destroy such medicines as they think not good.

APOTHEOSIS, in *Antiquity*, a heathen ceremony, whereby their emperors and great men were placed among the gods. The word is derived from απο, and Θεος, *God*. After the apotheosis, which they also called *deification* and *consecration*, temples, altars, and images were erected to the new deity; sacrifices, &c. were offered, and colleges of priests instituted. It was one of the doctrines of Pythagoras, which he had borrowed from the Chaldees, that virtuous persons after their death were raised into the order of the gods; and hence the ancients deified all the inventors of things useful to mankind, and those who had done any important services to the commonwealth.

APOTOME, in *Geometry*, the difference between two incommensurable lines.

Apotome, in *Music*, the difference between a greater and a lesser semi-tone; expressed by the ratio, 128, 125.

APOTROPÆ (from αποτρεπω, *I avert*), in the ancient poetry, verses composed for averting the wrath of incensed deities; and the deities invoked for averting any threatened misfortune were called *Apotrepeans*. They were also called *Alexiaci*, from αλεξω, *I drive away*; and *Averrunci*, from *averrunco*, which denotes the same.

APPARATUS, a term used to denote a complete set of instruments, or other utensils, belonging to any artist or machine.—Apparatus is also used as a title of several books composed in the form of catalogues, bibliothecas, dictionaries, &c. for the ease and convenicncy of study.

APPARENT, in a general sense, something that is visible to the eyes, or obvious to the understanding.

Apparent, among mathematicians and astronomers, denotes things as they appear to us, in contradistinction from real or true: thus we say, the apparent diameter, distance, magnitude, place, figure, &c. of bodies.

Apparent Heir, in *Law*. No inheritance can vest, nor can any person be the actual heir of another, till the ancestor is previously dead. *Nemo est hæres viventis*. Before that time the person who is next in the line of succession is called an *heir apparent*, or *heir presumptive*. Heirs *apparent* are those whose right of inheritance is indefeasible, provided they outlive the ancestor; as the eldest son or his issue, who must by the course of the common law be heirs to the father whenever he happens to die. Heirs *presumptive* are those who, if the ancestor should die immediately, would in the present circumstances be his heirs, but whose right of inheritance may be defeated by the contingency of some nearer heir being born; as a brother or nephew, whose presumptive succession may be destroyed by the birth of a child; or daughter, whose present hopes may be hereafter cut off by the birth of a son.

APPARITIONS.

Apparitions.

An apparition may be defined a spectral illusion, involuntarily generated, by means of which figures or forms, not present to the actual sense, are nevertheless depictured with a vividness and intensity sufficient to create a temporary belief of their reality. It is the result of the re-action of an excited imagination, renovating past feeling or impressions, with an energy proportioned to the degree of excitement; arranging them often in new and fantastical groups; and thus surrounding us with a phantasmagoria of the bodiless creation of the brain, so distinct both in outline and lineament, that, while the exciting cause continues to operate, the illusion of reality predominates over the mind with an intensity generally equal to, sometimes greater than, that of the impressions produced by actual perceptions. But although the illusion thus generated is necessarily co-existent with the state of excitement in which it has its origin; or, in other words, ceases to be active when the spectral phenomena vanish; it does not therefore follow that the mind, when it regains its ordinary condition, becomes immediately sensible of the hallucination under which it has for a time been labouring, or capable of distinguishing between the perceptions of sense and the phantasms of imagination. On the contrary, observation proves, what theory equally sanctions, that the conviction of reality generally outlasts the impressions which originally produced it; and that, so far from any suspicion of illusion being entertained, or any power of discriminating the actual from the imaginary being evinced, this conviction takes entire possession of the mind, and, in many instances, maintains its hold with a firmness which all the force of argument and reason is insufficient to overcome. Hence the tenacity, and we may add the universality, of the belief in apparitions; and hence also the prodigious diversity of forms under which these spectral illusions are presented in the popular legends and superstitions of different ages and countries;—a diversity, in fact, which seems commensurate with the incredible variety of influences, whether morbific or other, by which the imagination may be excited, and past feelings or impressions vividly renovated in consequence of its reaction on the organs of sense.

But however this may be, every one must, we think, agree that the subject of apparitions, viewed in connection with the philosophy of the human mind, is one of no mean importance: and, as it has more or less engaged the attention of philosophers from the earliest times, a brief and condensed historical view of the various theories which have been formed to account for these illusions may prove neither uninteresting nor uninstructive; while, in a work of this nature, intended to form a record of the great mass of human knowledge, such an outline appears to be not only requisite, but altogether indispensable.

In the ancient systems of philosophy we meet with the most opposite and contradictory opinions on the subject of spiritual essences, as well as in regard to their supposed occasional manifestations to the eye of flesh and blood. Ocellus Lucanus, one of the earliest of the Greek philosophers whose works have come down to our times, attempts to account for the appearances of the universe by having recourse to eternity and the circle. The circle he conceived to be the appropriate representative of eternity, if not absolutely identical with it; and as form, time, motion, and substance are without beginning and without end, so the universe, of which these are but parts, cannot have been generated, and, for the same reason, must be incapable of corruption. It is in fact a circle, without beginning and without end. But this stupendous circle is divided into parts totally dissimilar, by an isthmus which our fanciful author has placed somewhere in the neighbourhood of the moon, and which forms the boundary between the residence of the gods, where all is invariable, and the material universe, where every thing is in a state of endless change and revolution; the fates having drawn this line of demarcation to separate the passible and corruptible part from that which is impassive and incorruptible, or, in other words, subject to neither motion nor change. The changes on this side of the isthmus, however, are, according to Ocellus, just as endless as the state of things beyond it is immutable; for these changes revolve in a circle, which has neither beginning nor end, and consequently must be eternal; and hence the only difference between the two unequal compartments is, that, in the one, every thing is in a state of eternal rest, while, in the other, all is motion and revolution without end. It seems to follow, therefore, that the fates, in tracing this line of demarcation, have excluded the gods from all control over the material or corruptible part of the universe; and that the existence of an immortal essence, in the midst of the confusion of our lower world, is wholly impossible. Yet, in his fourth book, Ocellus speaks of the Deity conferring instincts and appetites on man: and, in a fragment preserved by Stobæus, he says that life is that which holds the body together, and that the cause of life is the soul; that the world is held together by harmony, and that the cause of harmony is the Deity; that states are held together by agreement, and that the cause of this agreement is the law;—sentiments which seem strangely at variance with the transcendental doctrine of eternity and the circle, by which all the varied phenomena of the universe were to be explained.

The atomic theory of Democritus, which some have recently attempted to revive, was adopted with certain modifications by Epicurus, and has been explained and illustrated by Lucretius in his philosophical poem on the *Nature of Things;* in which he enters with ardour and enthusiasm into the views of his favourite master, assails his enemies with the bitterest invective, combats every objection and difficulty, palliates and mystifies what cannot be defended, and pours forth his whole genius in support of the system which Democritus imagined and Epicurus taught. But neither the numbers nor the ingenuity of the poet have succeeded in recommending to any rational mind a theory based on the most extravagant assumptions, and involving consequences subversive of all those checks and restraints by which society is held together. At the same time, Lucretius is the first ancient writer who makes a formal attack on the popular notions entertained respecting ghosts and apparitions. These he justly regards as complete illusions; and maintains, conformably to the philosophy of Democritus and Epicurus, that so far from being spirits returned from the mansions of the dead, they are nothing more than attenuated films, pellicles, or membranes, cast off from the surface of all bodies, like the *exuviæ* or sloughs of reptiles;[1] or, in other words, the mere shadows

[1] It is often amusing as well as instructive to trace the history and descent of opinions. The strange notion of Lucretius, that apparitions are subtile films or images rising from the surfaces of bodies, appears to have entered more or less into many of the systems

of things which fear, and its offspring superstition, mistake for realities. The world, he observes, has long been in a state of horror and despair from dread of these incorporeal beings; and he acknowledges that his principal object, in expounding the doctrines of his master, is to rescue mankind from their vain apprehensions, by showing that all things are corporeal and dissoluble, not even excepting the soul itself; and thus destroying that *pneumatophobia* which, to use the language of Cudworth, makes men "have an irrational but desperate abhorrence from all spirits or incorporeal substances." Philosophy cannot certainly be better employed than in endeavouring to emancipate the mind from the unreal terrors by which it is so frequently enslaved. But it can scarcely fail to be a subject of regret that the philosophers of the Epicurean school should have sought to accomplish a laudable end by the intervention of means alike absurd and pernicious. Material necessity, and by consequence atheism, is at the root of all their doctrines; nor can these, therefore, be admitted to be true without overwhelming religion in the same ruin with superstition. Hence they are chargeable with the grievous fault of striking at a mass in order to reach an individual; of attempting to hew down the trunk in order to clear away a withered branch. At the same time they have the unquestionable merit of being the first who endeavoured, however unsuccessfully, to account, upon natural principles, for those appearances, which have in all ages more or less excited the fears and mingled with the superstitions of mankind.

But, without dwelling on particular systems of philosophy, we may observe generally, that although the belief in spectres or phantasms appears to be as old as the existence of the human race, this belief has in every instance been modified, and we may almost say regulated, by the prevalent pneumatological opinions respecting the soul, whether these have been derived from the writings of philosophers and poets, or imbibed from sources purely mythological. Strictly speaking, indeed, the character of superstitious credulity has been in all ages the same; but it is nevertheless true, that its particular objects have varied, as the opinions of mankind have changed respecting the sentient principle or cause of the vital phenomena.

In the case of the Greeks and Romans this is peculiarly remarkable; inasmuch as their superstitions afford ample evidence of the diversity of opinion that prevailed regarding the soul, yet are all more or less tinctured with its predominant colour and complexion. Democritus and Epicurus, as we have seen, considered it corporeal, but differed widely as to its substance; the Stoics maintained that it was ignited air; Hippo held that it was water; and Heraclitus was of opinion that, as the *anima mundi*, or soul of the world, was a vapour or exhalation from the moist elements, so the souls of animals were vapours or exhalations from their own bodies, or something external. Of those, again, who believed the soul to be incorporeal, some maintained that it was a substance, and immortal, while others asserted that it was neither. Thales taught that it was always in motion, and itself the origin or cause of that motion; Pythagoras regarded it as a self-moving monad or number; Plato thought it a substance conceivable only by the understanding, and moving according to harmony and number; Aristotle described it as the first *entelecheia*, or, to use the language of the translator of Nemesius, "the first continuall-motion of a bodie-naturall, having in it those instrumental parts, wherein was possibility of life;" and Dinarchus considered it a harmony of heat, cold, moisture, and dryness, or, in other words, a contradiction. Some imagined that there is but one universal soul, distributed in portions throughout all bodies, animate and inanimate, which doctrine was subsequently adopted by the Manicheans; while others taught that there is indeed one universal soul, but at the same time many different species. The illustrious head of the Platonic school seems to have believed in the existence of an universal soul, by means of which all things were supported in being; but he conceived that those only were to be accounted living creatures which had separate souls. The doctrine of transmigration was a natural consequence of these opinions, and, what is not a little remarkable, it seems to have been generally received among those philosophers who believed most firmly in the immortality of the soul; some making it pass indiscriminately into the bodies of plants and animals; others, into all organized structures; while a third set, conceiving that every kind of soul, whether rational or irrational, has a structure exactly suited to its own faculties and no other, confined it to structures of the same species. Plato distinguished these faculties into three classes, the vegetative, sensitive, and rational; and assigned a separate residence to each, the habitation of the last being, according to him, in the head.

Indeed the practice of arranging the logical entities, known by the names of *powers*, *faculties*, or *functions*, into different classes, and ascribing them to different species of souls, appears to have been prevalent at an early period, both among philosophers and poets. Empedocles allotted a rational and a sensitive soul to every animal; the rational one being derived from the gods, and the sentient a product of the four elements. But the ancients generally reserved the rational soul for man. In Homer's time the soul was divided into two species, the φρην and the θυμος, but afterwards, according to Diogenes Laertius, into three; while the body was considered tripartite, being composed of a mortal or crustaceous part,—a divine, ethereal, or luciform portion, appropriated to the φρην,—and an aerial, misty, or vaporous part, allotted to the θυμος. After the dissolution of the mortal part, however, the φρην was entirely separated from the θυμος, and a different habitation assigned to each. Hence we learn from Homer, that the φρην of Hercules was actually feasting with the gods, and making love to Hebe, at the very time that Ulysses was conversing with his θυμος in Hades. Similar notions were entertained by the Roman poets. According to them, every man possessed a threefold soul, which, after the dissolution of the body, resolved itself into the *Manes*, the *Anima* or *Spiritus*, and the *Umbra*, to each of which a different place was assigned. The Manes descended into the infernal regions, to inhabit

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on the same subject taught by the schoolmen in the middle ages, although the latter have not always remembered to acknowledge their obligations to the Roman poet. A similar view may also be detected in the reveries of the sympathetic philosophers, and particularly in the theory of the transmission of spirits propounded by Lavater; nor are there wanting traces of its existence in the popular superstitions both of ancient and modern times. Some of the older philosophers, on the other hand, appear to have construed the Epicurean doctrine of corporeal images much more literally than its great poetical expounder seems to have intended. Psellus, for instance, stoutly contends for the heretical doctrine of the materiality of demons, in which he seems to have been a stanch believer. Paracelsus, conceiving that the elements were inhabited by four kinds of demons—spirits, nymphs, pigmies, and salamanders—argues, in like manner, for the materiality of these non-descript beings, but seems inclined to think that they possessed *caro non-adamica*, which may easily be conceded to him. Cudworth maintains the materiality of angels; and some of his successors, improving upon their models, contend for the materiality of every thing in heaven above or in the earth beneath; thus completing the cycle of absurdity, and bringing us back at last to the Epicurean doctrine, from which we set out.

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either Tartarus or Elysium; the Anima ascended to the skies, to mingle with the gods; while the Umbra hovered around the tomb, as if unwilling to quit its connection with the body, of which it was the *wraith* or shadow. Hence Virgil represents Dido, when about to expire, as threatening to haunt Æneas with her *umbra*, at the same time consoling herself with the expectation that the tidings of his punishment will reach her *manes* in the shades below.[1] Nor are there wanting traces of an analogous belief in the popular superstitions of modern times. It is an article of ghostly faith, that apparitions are frequently seen near the spot where the gross or crustaceous body lies, waiting either until that body be interred, or until some crime be confessed and expiated; and, if tradition may be in aught believed, the spectral appearances of individuals have occasionally been observed previous to their death, of which, indeed, these illusions are the sure forerunners or harbingers. Among the Greeks such spectres were denominated φαντασματα, πνευματα, ειδωλα, apparitions, aerial forms, likenesses; while the Romans called them *spectra*, *umbræ*, *simulacra*, *manes*, *imagines*, visions, shades, similitudes, ghosts, and images.

Some, however, thought that spectral illusions were souls visibly expanded; but others doubted whether they were ψυχαι, the principles of life, or merely the vehicles of such principles. The ghost of Hercules, which Ulysses saw in Hades, was, according to Homer, his ψυχη and ειδωλον, or his corporeal likeness, animated by his θυμος; and such *simulacra* were supposed to speak, to complain, to feel hunger, and to receive nourishment, though probably at that table only where spare fast diets with the gods. It may also be observed, that, according to Virgil, the *umbræ* were the *animæ* or souls themselves, and were all sprung from the same source as the soul of the universe, namely, from ether or elemental fire. Hence, the *umbræ* which Æneas beheld in the shades below, when he went thither to visit his father Anchises, were ethereal souls, receiving rewards or suffering punishments for their past deeds; some for inexpiable crimes, which rendered their punishments eternal; others for offences, the stains of which might be obliterated, and who, consequently, were exposed for a series of ages to the action of air, water, or fire, "until the crimes done in their days of nature were burned and purged away." At the same time, it is quite true, as Dr Barclay has remarked, that "in most, if not in all of these *simulacra*, the dress and its fashions were represented as well as the body; while, in all the poetical regions of the dead, chariots and various species of armour were honoured likewise with their separate *simulacra*; so that these regions, as appears from the *Odyssey*, *Æneid*, and *Edda*, were just the *simulacra* of the manners, opinions, customs, and fashions, that characterized the times and countries in which their poetical historians flourished."[2]

To the superstitions of Greece and Rome we are also indebted for those subordinate spirits named *demons* or *genii*, who for many centuries were the subject of numberless spectral illusions. These intermediate beings were distinguished by the Platonists from the superior deities of the popular mythology on the one hand, and from heroes or demigods on the other. They were divided into beneficent and malignant spirits; and, according to the conceptions of the Platonic philosophers, differed in no material degree from the good and evil angels of the Christian belief. Socrates fancied himself constantly attended by a demon or genius, to whose inspirations or suggestions he conceived himself indebted for those views of practical wisdom and philosophy which have rendered his name so deservedly illustrious. Among the Romans, again, genii were supposed to be messengers of the gods, employed, on particular occasions, to give intimation to men of approaching events, or calamities soon to befall them. Of this kind was the phantasm which appeared to Brutus sitting dejected in his tent, and told him that they would meet again at Philippi.[3] Cornelius Sylla received a similar intimation from an apparition, which accosted him by his name: and, concluding that his death was at hand, the ex-dictator prepared himself for the event, which took place the following evening, in consequence of a sudden and violent attack of fever. Cassius Severus, the poet, a short time before he was slain by order of Augustus, saw, during the night, a human form of gigantic size, with his skin black, his countenance squalid, his beard grizzled, and his hair dishevelled; a phantasm not unlike the evil genius so powerfully described by Lord Byron as appearing to Manfred in the hour of his agony.[4] The emperor Julian, on

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[1] This notion of a threefold soul is well expressed in the following lines, attributed to Ovid:—

Bis duo sunt homini: *Manes*, *Caro*, *Spiritus*, *Umbra*:
Quatuor ista loci bis duo suscipiunt;
Terra tegit *Carnem*, tumulum circumvolat *Umbra*,
Orcus habet *Manes*, *Spiritus* astra petit.

[2] *Inquiry into the Opinions, ancient and modern, concerning Life and Organization*, p. 14. By John Barclay, M. D. Edinb. 1822, 8vo.

[3] The observations of Sir Walter Scott on the spectre which appeared to Brutus on the eve of the battle of Philippi are equally just and philosophical, in so far as regards the exciting cause:—"The anticipation of a dubious battle, with all the doubt and uncertainty of its event, and the conviction that it must involve his own fate, and that of his country, was powerful enough to conjure up to the anxious eye of Brutus the spectre of his murdered friend Cæsar, respecting whose death he perhaps thought himself less justified than at the Ides of March, since, instead of having achieved the freedom of Rome, the event had only been the renewal of civil wars, and the issue might appear most likely to conclude in the total subjection of liberty. It is not miraculous that the masculine spirit of Marcus Brutus, surrounded by darkness and solitude, distracted probably by the recollection of the kindness and favour of the great individual whom he had put to death to avenge the wrongs of his country, though by the slaughter of his own friend, should at length place before his eyes in person the appearance which termed itself his evil genius, and promised again to meet him at Philippi. Brutus' own intentions, and his knowledge of the military art, had probably long since assured him that the decision of the civil war must take place at or near that place; and allowing that his own imagination supplied that part of his dialogue with the spectre, there is nothing else which might not be fashioned in a vivid dream or a waking reverie, approaching, in absorbing and engrossing character, the usual matter of which dreams consist. That Brutus, well acquainted with the opinions of the Platonists should be disposed to receive without doubt the idea that he had seen a real apparition, and was not likely to scrutinize very minutely the supposed vision, may be naturally conceived; and it was also natural to think, that although no one saw the figure but himself his contemporaries were little disposed to examine the testimony of a man so eminent, by the strict rules of cross-examination and conflicting evidence, which they might have thought applicable to another person and a less dignified occasion." (*Demonology and Witchcraft*, p. 10, 11.)

[4] The description alluded to in the text is as follows:—

I see a dusk and awful figure rise
Like an infernal god from out the earth;
His face wrapt in a mantle, and his form
Robed as with angry clouds; he stands between
Thyself and me, but I do fear him not.

one occasion, while engaged in an expedition, beheld a spectre or apparition clad in rags, yet bearing in its hands a horn of plenty, covered with a linen cloth; and thus emblematically attired, the spirit stalked mournfully past the hangings of the Apostate's tent. Lastly, Dio of Syracuse was visited by one of the Furies in person, not in the shape of a vixen, but of a horrid phantasm, the appearance of which was considered by the soothsayers indicative of the death of his son (which occurred soon after), as well as of his own approaching dissolution. Many other instances might be given of similar illusions, evidently conjured up by the workings of an excited imagination re-acting on the organs of sense, and believed to be harbingers of "coming events;" but those we have mentioned are sufficient to show the opinions entertained in regard to such apparitions, and to exemplify the power which superstition exercises over the mind when unenlightened by a sound and rational philosophy. We may add, however, that demons or genii were frequently regarded as private monitors, who by their insinuations disposed each man to good or evil actions, and were not only reporters of his crimes in this life, but registrars of them against his trials in the next; an opinion which the Romans evidently derived from the Greeks, among whom a similar notion prevailed from an early period of their history.

Among the Jews and early Christians we find analogous superstitions, though, as might have been expected, much more varied and complex in their details. Like the Greeks and Romans, the Jews believed in good and evil spirits, to the latter of which the name of demons came to be exclusively appropriated; and this belief they founded partly on the statements contained in their own Scriptures, partly on notions derived from the Pagans. Some of their angels were supposed to be created out of the elements of fire, others out of the wind; and both classes forfeited their immortality whenever they issued from their allotted place. Their business was to instruct mankind in wisdom and knowledge; and every thing in the world was conceived to be under their government. Even to the herbs of the field, supposed to exceed twenty thousand in number, presiding angels were assigned; and rain, hail, thunder, lightning, fire, fishes, reptiles, animals, men, cities, empires, nations, were all respectively under the dominion of spiritual powers. Nor were their demons less numerous than their tutelar genii or angels, as any one may easily satisfy himself by consulting the Talmud, in which this multitudinous array of spirits is very minutely described. Every form of evil, whether physical or moral, was ascribed to the direct agency of one or other of this subordinate tribe of devils, whose sole business it was to work mischief, and who were also conceived to be indefatigable in the exercise of their calling; so much so that, in the constant warfare carried on between the good and evil spirits, it is far from being clear that the former had always the advantage. Demoniacal possession is only one form under which this infernal agency manifested itself. In a word, the superstitious Jew who devoutly believed in the wild vagaries engendered by the seething imaginations of the Rabbin, might have said with the Roman satirist, *Nostra regio tam plena est numinibus, ut facilius possis deum quam hominem invenire.*

It is not to be wondered at, however much it may be regretted, that many of these notions accompanied the spreading of the gospel, and communicated a taint of Jewish superstition to the faith of the first Christians. The mind is unable at once to emancipate itself from the dominion of delusions, which have been consecrated by time and sanctioned by authority, and which, insensibly imbibed by education and habit, address themselves to the natural fears and feelings of the human heart. Hence it ought not to surprise us that, not only at the commencement of the Christian dispensation, but during a very long period afterwards, evident traces may be discovered of the prevalence of the popular opinion mentioned by Symmachus, namely, "that the Divine Being had distributed to cities various guardians, and that as souls were communicated to infants at their birth, so particular tutelary spirits were assigned to particular societies of men." On the other hand, some sects, puzzled to account for the origin of evil, and affecting philosophy without possessing a philosophical spirit, systematized the Jewish superstitions, by combining them with the creed of Zoroaster, and promulgating formally the doctrine of a ceaseless antagonism between the good and evil principles, personified in the Ormusd and Ahriman of the Persian mythology; while others, again, imitating the classification of the different orders of spirits by Plato, attempted a similar arrangement with respect to the hierarchy of angels.[1] Both systems involved the constant agency of spiritual power in the government of the world, and admitted also its occasional manifestation in the shape of apparitions. Among the Fathers, however, great diversity of opinion prevailed in regard to these illusions, which no one seems to have dreamt of attempting to explain by reference to natural causes. Origen, for example, conceived that souls, tainted with the guilt of flagrant crimes, and not purged from their impurity, were either confined in a species of limbo, or attached to particular spots, where, within certain limits, they might ramble about at will. Athanasius maintained that souls, when they were once released from their bodies, held no more communion with mortal men; and the more rational of the early theologians condemned all visions and apparitions that had not the unequivocal sanction of the Deity, our Saviour, or the angels. Augustin also remarked that, if souls did actually walk and visit their friends, he was convinced his mother, who had followed him by land and sea, would have shown herself to him, in order to inform him what she had learned in another state, as well as to give him much useful advice. Others, however, yielded to the current superstitions, which they laboured to reconcile with the doctrines and statements of Holy Writ.

But it was not until a much later period of Christianity that more decided doctrines were established relative to the origin and nature of demons; and it is principally to the Papal Church of Rome that the unenviable honour is due, of adopting and methodizing the vagaries of the Pagans, as well as the legends of the Talmud, and thus originating that system of demonology which, from various causes, grew to such a monstrous height during the middle ages, as completely to overwhelm Christianity under its revolting and abominable fictions. When this church recognised the doctrine, that the functions of ministering angels were assigned to the spirits of departed saints, she opened a door for the admission of the abominations of Paganism in a new form,[2] and the encouragement of su-

[1] We allude to the Gnostics, according to whom the gradations in the hierarchy of angels stood thus:—The first and highest order was named seraphim, and the second cherubim; the third was the order of thrones, and the fourth that of dominions; the fifth was the order of virtues, the sixth of powers, the seventh of principalities, the eighth of archangels, and the ninth or lowest that of angels. This fable, as Dr Hibbert remarks, was pointedly censured by the apostles; yet, nevertheless, it outlived the pneumatologists of the middle ages, and is scarcely even now exploded.

[2] It is impossible not to feel that the reproaches which Reginald Scot casts upon the church of Rome, on account of her heathenism, are well merited, and that their chief bitterness is not so much in the unrelenting irony of that dauntless writer, as in

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perstitions, utterly subversive of all true religion; while, on the other hand, by countenancing and fostering the frantic extravagances of the demonologists, more particularly in regard to the impossible crime of witchcraft, she did all in her power to perpetuate the empire of delusion, and at the same time made herself responsible for the multiplied atrocities which were committed under its influence. She became, in fact, the nursing mother of lies, and the avowed patroness of the powers of darkness. The devil and his legions were everywhere and in every thing: diabolical agency was supposed to be unremitting and universal. The priests strengthened their dominion by practising conjurations and exorcisms; while the monks fabricated legends suited to the prevailing taste, and calculated to thicken the delusion which added so greatly to their spiritual power. In the meanwhile Satan's invisible world was displayed with a topographical minuteness of detail, which could scarcely have proved very agreeable to that great personage. The nature, history, and rank of devils were curiously inquired into, and the point of precedency in the infernal hierarchy settled to a nicety; the various forms assumed by them in the course of their operations upon earth were also very fully described; the different tests by which their presence might be detected were given with something like scientific precision; and, what is still more extraordinary, the number of these fallen spirits was determined to a fraction. In short, the wildest fictions which imagination ever coined were gravely received as matters of faith and doctrine; while a new impulse and direction were thereby given to popular superstition, which the ghostly legends of the Church had far outstripped in point of extravagance.

At this period, accordingly, the belief in apparitions was universal, and people would have sooner doubted their own existence or identity, than ventured to call in question the most grotesque fooleries which the human fancy ever imagined. Even the Reformation, which overthrew so many errors, eradicated so many prejudices, and destroyed so many delusions, left this one as hideous as ever. And so far from proving himself superior to the vain imaginations and follies of his time, Martin Luther has left abundant evidence to show, that he was as deeply imbued with superstitious credulity, and believed as firmly in diabolical apparitions, as the most illiterate monk in the church which he shook to its very foundations. He even fancied that the devil took a particular pleasure in annoying him, doubtless from pique at the successful resistance he had opposed to the power and pretensions of Rome; and he relates several conversations, or rather altercations, he had had with the Evil One, in which, by his own showing, the reformer had clearly the best of it (so far at least as abuse was concerned), and generally ended by putting the fallen spirit to flight. On one occasion in particular, when the Tempter had intruded himself rather unseasonably, and had chosen to assume "a glorious form of our Saviour Christ," the reformer, who at first expected a revelation, lost all temper as soon as he discovered the real character of his visitant, and exclaimed fiercely, "Away, thou confounded devil; I know no other Christ than he that was crucified, and who, in his word, is pictured and preached unto me; whereupon," he adds, "the image vanished, which was *the very Devil himself*." And all his narratives of losses or misfortunes which happened to individuals in whom he felt an interest commonly end with the pithy solution, "This did the devil."[1] Nor was he at all singular in entertaining these notions, which in fact were equally shared by the other reformers, and continued long afterwards to exert a most powerful influence upon the faith of all Europe; particularly in regard to the imaginary crime of witchcraft, for which so many unhappy wretches suffered death both in this and in other countries.

It would be vain to inquire whether, at the period in question, or indeed for a long time afterwards, any attempt was made to expose the impostures which were continually practised, or to account, upon rational principles, for those spectral illusions which are known to be generated in particular states of the body and mind. Such an idea seems never to have entered the head of any one; and indeed if a sceptic had arisen bold enough to insinuate even a suspicion of the fallacy of the received opinions, he would have been sacrificed without mercy to the bloody Moloch, who was then the object of almost universal homage. He might perhaps have denied his God, and blasphemed his Saviour with impunity; but if he had dared to dispute the agency of the Devil, to doubt the reality of his appearances, or in any manner of way to assail the creed of the

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their truth. "Surelie," says he, "there were in the Popish church more of these antichristian gods in number, more in common, more private, more publicke, more for lewd purposes, and more for no purpose, than among all the heathen, either heretofore or at this present time; for I dare undertake, that for everie heathen idol I might pronounce twenty out of the Popish church. For there were proper idols of every nation, as St George on horseback for England, St Andrew for Burgundie and Scotland, St Michael for France, St James for Spain, St Patrike for Ireland, St Davie for Wales, St Peter for Rome and some part of Italie. Had not every citie in all the Pope's dominions his severall patrone; as Paule for London, Denis for Paris, Ambrose for Millen (Milan), Louen for Gaunt, Romball for Mackline, St Mark's Lion for Venice, the three magician kings for Cullen, and so of other? Yea, had they not for everie small towne and everie village and parish (the names whereof I am not at liberty to repeat) a severall idol: as St Sepulchre for one, St Bride for another; St All Hallowes, All Saints, and Our Ladie for all at once? Had they not hee idols and shee idols, some for men, some for women, some for beasts, and some for fowels? And do you not thinke that St Martine might be opposed to Bacchus? If St Martine be too weak, we have St Urbane, St Clement, and manie others to assist him. Was Venus and Meretrix an advocate for whores among the Gentiles? Behold, there were in the Romish church to encounter them, St Aphra, St Aphrodite, and St Maudline. Was there such a traitor among the heathen idols as St Thomas Becket? or such a whore as St Bridget? I warrant you, St Hugh was as good a huntsman as Anubis. Was Vulcane the protector of the heathen smithes? Yea, forsooth, and St Euloge was patron for ours. Our painters had Luke, our weavers had Steven, our millars had Arnold, our potters had St Gore with a devil on his shoulders and a pot in his hand. Was there a better horseleech among the gods of the Gentiles than St Loy? or a better sow-gelder than St Anthonie? or a better tooth-drawer than St Apolline? I believe that Apollo Parnopeius was no better a rat-catcher than St Gertrude, who hath the Pope's patent and commendation therefore." And so honest Reginald proceeds with his expostulatory comparison, which, in the true spirit of his age (when the phantasms of demonology maintained their dominion even over those minds which had cast off the fetters of the church of Rome), he concludes by declaring that "all these antichristian gods, otherwise called popish devils, are as rank devils" as any that are spoken of in the Psalms, or mentioned in other parts of Scripture. (See *Discourse on Devils and Spirits*, appended to the *Discourse of Witchcraft*.)

[1] Mr Coleridge, in his *Friend*, vol. ii. p. 336, gives the following natural and rational account of the origin of Luther's visions:—"Had Luther been himself a prince, he could not have desired better treatment than he received during his eight months' stay in the Wartzburg: and in consequence of a more luxurious diet than he had been accustomed to, he was plagued with temptations both from the 'flesh and the devil.' It is evident from his letters that he suffered under great irritability of his nervous system, the common effect of deranged digestion in men of sedentary habits, who are at the same time intense thinkers; and this irritability adding to and vivifying the impressions made upon him in early life, and fostered by the theological systems of his manhood, is abundantly sufficient to explain all his apparitions, and all his mighty combats with evil spirits."

demonologists, it would have been better for him that a millstone had been hanged about his neck, and he had been cast into the midst of the sea. On the gibbet or at the stake, he would infallibly have expiated the audacity of his unbelief. In process of time, however, humanity began to lift up her voice, and reason seemed to recover from the long trance into which the reign of delusion had thrown her. Scattered rays of light broke in from various quarters; as knowledge advanced, the mind became expanded; a spirit of inquiry was gradually developed; the learned began to reason and to doubt; and the empire of superstition was shaken. For long, the vulgar creed, which had been deeply tinged with the monstrosities and follies we have alluded to, resisted the influence of the causes which were now at work, sapping the foundations of the whole edifice of delusion; and even yet, amidst all the light with which we are surrounded, some corners of the world still remain unilluminated. But a change had come over the spirit of the dream in which the nations had so long been entranced; and men, having begun to examine, soon learned to doubt and disbelieve.

About the end of the sixteenth and beginning of the seventeenth century, various theories were suggested to account for those extasies of imagination in which spectral illusions have their origin; and, in the memorable experiment of palingenesis, or the resurrection of plants (a secret known to Digby, Kircher, Schot, Gafferel, Vallemont, and others), an explanation was sought of apparitions, which were thought to be reproduced in a similar manner. To this succeeded the doctrine of astral spirits, as they were called; which was an attempt to combine the metaphysical opinions then entertained respecting ideas, with the conclusions deduced from the experiment of palingenesis, or the reproduction of a rose, like the phenix from its ashes. Others, again, referred all the phenomena of extasies, hallucinations, and apparitions to the phantasy or imagination, which was justly conceived to exert a powerful influence over the mind, and to be primarily concerned in the production of those illusions which give birth to a belief in apparitions. Van Helmont, Hoffmann, and most of the medical inquirers of that age, adopted this explanation; and several passages in Hamlet show that such was also the belief entertained by our immortal dramatist. If the imagination, it was argued, can induce a particular form or mark upon the fœtus in the womb, much more must it be capable of vivifying and clothing ideas in the mind so as to create an illusion of reality. Nor were these inquiries confined to apparitions alone. In the year 1701 the celebrated Thomasius distinguished himself by an inaugural dissertation *De Crimine Magiæ*, in which he attacked, with irresistible force of reasoning, the prevalent belief in witchcraft, and boldly exposed the insane and murderous delusions which had conducted whole hecatombs of victims to the stake. This thesis, embodying a formal attack on demonology, was publicly read in the university of Halle, which, to its honour, greeted with applause the bold scepticism of the young jurisconsult; and so well did the latter perform his task, that his juvenile production is still considered valuable, both for its facts and its reasonings.

The approbation with which the inaugural dissertation of Thomasius was at first received, and the merited celebrity which it subsequently obtained, may be considered as proofs that more rational opinions had already begun to prevail, at least among the learned; and that the minds of men were in some measure prepared for the reception of the new doctrines he so fearlessly promulgated. Popular credulity, indeed, still continued gaping and greedy: it still yearned, with an unabated craving, for the supernatural and the diabolical. But the softening and humanizing influence of knowledge had imperceptibly mitigated the ferocity which the belief in demonology had originally inspired; and, although the public generally were not more enlightened or less superstitious, the magistrate had insensibly become more humane, and the fires of persecution burned less frequently and fiercely. The tide, in short, had obviously turned; and the first indication of the reflux is afforded by the justly-celebrated discourse in question.

At the same time, Thomasius, though among the foremost, was not the first, to assail demonology. This honour of right belongs to Dr Balthasar Bekker,[1] a protestant clergyman at Amsterdam, and author of a learned

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[1] Balthasar Bekker was a native of Metselawier in Friesland, where he was born in the year 1634. He had no other master than his father, who was the pastor or clergyman of the place, until he attained the age of sixteen, when he went to prosecute his studies at Groningen, and afterwards at Franeker. In the first of these universities Alting was his master in Hebrew, and conceived a strong affection for his pupil, whom he subsequently supported against his numerous enemies and persecutors. Having completed his studies at Franeker, Bekker was appointed rector of a Latin school, and afterwards pastor at Ooterlitten, where he signalized himself by his zeal in the discharge of his duty, and in consequence drew down upon himself the enmity of his less active colleagues. In 1666 he took the degree of Doctor of Divinity at Franeker, together with the situation of pastor, and soon afterwards published a tract entitled *De Philosophia Cartesiana Admonitio Sincera*, in which he attempted to prove that the Cartesian philosophy, a taste for which he was anxious to diffuse, might be easily allied with the study of theology. This piece appears to have procured him nothing but enemies, the number of whom was considerably increased by the publication, about the same period, of two catechisms, under the absurd titles of *Gesneden Brood* and *Vaste Spyze*; in the last of which he advanced some peculiar opinions concerning the state of Adam before his fall, the nature and duration of the pains of hell, the ecclesiastical hierarchy, and the rights of ecclesiastical assemblies. His jealous colleagues accused him of Socinianism and Cartesianism; and although he wrote a defence of his opinions, and showed a disposition to alter or retract every thing that might be conceived contrary to the faith, the synod, disregarding his concessions, prohibited the printing of the *Vaste Spyze* under a severe pecuniary penalty. Chagrined at this proceeding, he quitted Franeker, and became successively pastor at Loenen and Wesop, chaplain of a regiment of the line, and finally, in 1679, established himself at Amsterdam, where new writings soon kindled up afresh the animosity of his brethren. He combated the prejudices of the vulgar in a tract which he published on the occasion of the appearance of a comet in 1680 and 1681; and, in his *Recherches sur les Comètes*, published in 1683, he adopted a course of argument similar to that pursued by Bayle, showing that comets are neither presages nor forerunners of calamities, as was then currently believed, and ridiculing the popular notions and superstitions on this subject. This little work, replete with sound and just ideas, was well received. But a very different fate awaited another and far more important one, which he published soon after, under the title of *De Betooverde Wereld*, or *The World Bewitched*; a performance which justly entitles him to be ranked with the freest, boldest, and most philosophical thinkers which any age or country has produced. *De Betooverde Wereld* was first printed at Franeker, and afterwards reprinted several times at Amsterdam, where a French translation, in four volumes 12mo, appeared in 1694; and a new edition was published at Deventer so late as the year 1737. This work, which had the misfortune to appear too soon, is the one which has most contributed to render Bekker's name famous, both from its own intrinsic merits, and from the fury of calumny and persecution to which it exposed him. If formerly he was regarded as a Cartesian and Socinian, he was now denounced as a downright Sadducee. All pens were in motion against him; and before Bekker had time to reply to the host of adversaries by whom he was assailed, his book was submitted to the censure of the ecclesiastical council. The author published a defence or apology, *Schriftelike Satisfactie*, in which he protested against all malignant interpretations of his book, and avowed his belief in the existence of the devil, but at the same time expressed his conviction that

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work, first published in Dutch and afterwards in French entitled, *The World Bewitched, or an Examination of the Common Opinions concerning Spirits, their Nature, their Administration, and their Operations, and also concerning the Effects which Men are capable of producing by their Intercourse and their Virtue:* a work which Thomasius must in all probability have seen and consulted, as the French edition appeared in 1694, ten years prior to the publication of his thesis; and the persecution which the author experienced on account of his scepticism about devils and their supposed operations could scarcely fail to make it generally known. But be this as it may, the performance of the Dutchman is certainly an extraordinary one for the time at which it appeared; being not more remarkable for the learning it displays than for the boldness with which it combats the received opinions regarding spirits, and the exceeding ingenuity with which the various frauds and impostures of the demonologists are detected and exposed.

The author sets out by giving an able and accurate exposition of the opinions, or rather fables, of the Pagans, Jews, and Mahometans, on the subject of demons, or good and evil spirits, with their supposed attributes, functions, and operations, as described in their different mythological systems, and particularly as received at the period when Christianity was first preached to the world. He then proceeds to show that the early Christians insensibly introduced and mixed up with the new faith many of the fictions of Paganism and Judaism; and that this corrupting process went on continually increasing, until it attained a maximum under the Papacy, when all the miracles which the Pagans had supposed to have been performed by their demons or inferior divinities were ascribed to angels, to the souls of sinful men, and, above all, to the power of the devil. In particular, he traces the progress of Manicheism, from the time when it first assumed consistency and form; and shows, in a very striking manner, how this heresy, though anathematized by the Church, gradually insinuated itself into the very core of all her doctrines respecting spiritual agency in human affairs; and thus became part and parcel of the creed which she ordained men to believe under the penalty of eternal damnation. It is to this unfortunate intermixture of Paganism with Christianity, therefore, that he ascribes all the abominations with which the latter was polluted; and hence he contends, " que plus on se trouve éloigné du Paganisme, soit pour le temps, soit pour les lieux, moins on ajoute de foi à toutes les choses qui regardent le diable et son pouvoir." But his great principle is, that the doctrines of the demonologists are not more repugnant to reason, than adverse to Scripture when rationally interpreted. Revelation, he holds, contains nothing to sanction such doctrines; and he supports this opinion by a detailed examination of all the cases mentioned in holy writ where the devil is either represented as appearing to men, or exercising an immediate power over their bodies or minds,—explaining them on rational or natural principles with singular skill and ingenuity. For example, he rejects as absurd the idea of demoniacal possession, though generally received by the Protestant as well as the Catholic Church; and regards the cases of *dæmonia* mentioned in the New Testament as not properly " une expulsion des diables, mais une guérison miraculeuse de maladies incurables." Again, with regard to the metaphysical doctrine of the demonologists, " qu'un esprit en tant qu'esprit, et d'autant plus même qu'il est un esprit, peut sans corps agir sur toutes sortes de corps et sur les autres esprits," he does not meet it by a direct denial, but calls upon his adversaries to prove their own fundamental proposition. " Je demande des preuves de cette thèse," says he, in his *Abrégé* and *Défense;* " et parce que cette demande est imprévue et extraordinaire, et sur laquelle par conséquent on ne s'étoit préparé, on prend ma demande pour une négative.—I do not deny the truth of it, if it be true, but neither can I admit the truth of it till it be proved, nor can you assume it without proof, and then call upon others to believe it." Upon the same principle he demonstrates the utter absurdity of all supposed compacts with the devil, which he considers as not more impossible in themselves than incapable " subsister, en aucune manière, avec ce qui est contenue dans la doctrine de l'Ecriture, ni avec l'économie de l'alliance de Dieu, tant avant la Loi que sous la Loi, et moins encore sous l'Evangile."

But the most interesting part of this curious work, perhaps, is that where the author exposes, with equal skill and severity, the various frauds and impostures which have been practised upon ignorant credulity, and have thus given rise to all the delusions of witchcraft, and to a vast majority of those on the subject of apparitions. He examines in detail a great number of cases of both descriptions, and never fails to detect and drag to light the deception in which they originated. He exhibits a commerce of imposture and dupery, of fraud and credulity, often amusing, always instructive, sometimes truly horrible with reference to its consequences. In short, his exposure is complete and triumphant. " Les diables qui se faisoient voir et entendre," says he, " étoient dans la cervelle des hommes; si non, ils étoient faits de chair et d'os;" and he holds, qu'il n'y auroit point du tout de sorcellerie, si l'on ne croyoit pas qu'il y en eust." But this being once believed, and the magistrate having set himself to punish an imaginary and impossible crime, the belief became stronger as the fires of persecution grew hotter, and each new holocaust only prepared fresh victims for the

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Satan was chained in the bottom of hell, and consequently prevented from intermeddling with human affairs. The council had the good sense to be satisfied with this explanation; but the clergy of Holland, irritated at the indulgence shown to Bekker, overwhelmed it with reclamations, and forced it, by dint of clamour, to examine the affair more seriously. Bekker then demanded that the matter should be carried before the synod, and presented a new defence of his opinions; but the synod condemned the work, and deposed the author from his ministerial charge. This judgment was received with a sort of triumph by the clergy, and attacked by some of the author's friends in a clever tract, entitled, *Le Diable Triomphant, parlant sur le Mont Parnasse.* The synod, however, adhered to its sentence, and Bekker died of a pleurisy in 1698, without having been reinstated in his charge. On the occasion of his deposition, his enemies caused a medal to be struck, representing the devil dressed in clerical costume, and mounted upon an ass, with a sort of banner in his hand, emblematical of the triumph which the clergy had obtained in the synod. But this triumph was short-lived; for although the synod declared to a man in favour of the devil, the rational part of the world were ultimately convinced by the reasonings of the deposed minister; which soon began to gain ground, and contributed largely to emancipate the minds of men from the thraldom of a bloody and debasing superstition. Bekker, it seems, though a profound theologian and an able scholar, was a very ugly man, with bandy legs, and a nose and chin so prominent that they almost met; peculiarities which gave rise to the following epigram of Lamonnoye, prefixed to some of the French editions of *The World Bewitched:*—

Oui, par toi de Satan la puissance est brisée;
Mais tu n'as cependant pas encore assez fait;
Pour nous ôter du Diable entièrement l'idée,
Bekker, supprime ton portrait.

sacrifice. Dr Bekker concludes his remarkable work in these words:—"Si les souverains et les magistrats punissoient aussi exactement ceux qui accusent les autres de magic, qu'il y en a qui sont prestes à punir ceux qui sont accusés, lesquels ils jettent à la première délation dans les fers, et qu'ils donnassent la question seulement la moitié aussi forte aux délateurs, pour donner des preuves de leurs accusation, qu'ils la donnent à ceux-là pour confesser, je suis certain qu'ils n'auroient pas beaucoup besoin de bois pour les bruler. Car quoique dans le commencement ils eussent beaucoup à faire avant que cette nouvelle manière de plaider fust venue à leur connoissance, cela ne laisseroit pas de se passer bientost, lorsqu'ils verroient, qu'en accusant, ils se mettroient dans l'obligation de prouver ce qu'ils avanceroient, ou de subir la peine de la faute, en cas qu'ils ne peussent la prouver." Whoever takes the trouble to read the records of our own criminal procedure, and to observe the nature of the evidence upon which persons accused of witchcraft and sorcery were "fylit, convict, and brynt," will probably be convinced that these records would have been disgraced by few such atrocities had Dr Bekker's principle been adopted and acted upon. But a different form of practice was followed, of which it may with literal truth be said, *Siquidem accusásse hic sufficit, quis insons habebitur?*[1]

Upon the whole, it is impossible not to regard the production of the Dutch divine as in many respects one of the most remarkable extant, considering the time when it appeared; nor are we aware of any similar instance of a writer who so far outstripped his age, and evinced so complete a superiority to its prejudices and superstitions. Bekker's work, indeed, had the misfortune to appear too soon; and of this he was early made sensible, by the torrent of abuse with which he was assailed, and the persecution he was called upon to undergo. What must have been the boldness and courage of that man who, in an age when the wildest fictions of demonology and witchcraft were implicitly, nay almost universally believed, commenced his attack on them by declaring, "C'est pour détruire cette vaine idole de la crédulité populaire que j'ai écrit mon livre: si le démon s'en fâche, qu'il emploie sa puissance pour m'en punir; s'il est Dieu, qu'il se défende lui-même, et qu'il s'en prenne à moi qui ait renversé ses autels!"

When Lucian ridiculed apparitions, and laughed at those who believed in them, he thought only of the lies, impostures, and absurdities which the ignorant and credulous had received as undoubted facts. All the passions exaggerate, and none more so than that of fear, the parent of superstition. Hence every thing seen through such a medium is beheld distorted, and out of all natural proportion. But, in cases of this description, it too frequently happens that the love of the marvellous comes in to finish the caricature which passion had commenced; and that imagination performs the double function of first imposing upon the seer himself, and afterwards contributing to enable him to impose still farther upon others. It is certain, indeed, that most if not all of the ghost stories which have been told are grossly exaggerated in almost every particular. Indeed, with the exception of Nicolai's truly philosophical narrative of the spectral illusions, which he beheld during a period of strong excitement produced by various misfortunes,[2] we scarcely know of a single case which does not bear on the face of it evident marks of embellishment and romance. Hence the difficulty of forming any theory of apparitions, to which, as matters stand, strong objections may not be taken, on the ground of its not embracing all, or even a majority, of the cases reported. We still want data upon which we can safely rely: and this want is to be ascribed mainly, if not solely, to the circumstance that every reporter was not a Nicolai; and that most of them have chosen rather to pander to the appetite for the marvellous than to tell their story simply and rationally. Lucian perceived this tendency of human nature, and unphilosophically ridiculed all apparitions as gross impositions on the credulity of the world; while the inquirers of the period to which we refer went to the opposite extreme, and, admitting every legend as authentic, racked their brains to account for what was in its own nature inexplicable upon any metaphysical theory. They never thought of cross-interrogating the witnesses before proceeding to consider the import of their testimony, or of endeavouring to test the credibility of the evidence before attempting to construct a theory out of it. They believed every thing without discrimination, and therefore could account for nothing. Thus Reginald Scot ridicules the paganism of the Church of Rome, yet comes to the conclusion that all her saints are as authentic devils as any in Pandemonium. Burton is scarcely more fortunate; and later inquirers, who finally gave up Satan and his invisible world altogether, landed in absurdities nearly as great as those they attempted to expose, though of course incomparably less mischievous.

But the progress of discovery and knowledge, independently of all theory, has cleared away many of the marvels which puzzled our ancestors. The devils, for example, which Benvenuto Cellini saw when he got into the conjurer's circle are now known to have been produced by a magic lantern; the Giant of the Broken, in the Hartz Mountains, has lost all his terrors since it was discovered that the spectre which had frightened men for ages is nothing more than the image of the individual who happens to be on the mountain-top at sun-rise reflected from the clouds beyond in gigantic proportions; and the Fata Morgana, as well as the Mirage, are now classed as pseudo-apparitions.

Of the more modern attempts to account for apparitions, the first which we shall notice is attributed to Meyer, and proceeds upon a particular theory respecting the origin of ideas, the conception of which appears to have

[1] One of the charges, it seems, against Dr Bekker, in the libel tried by the synod which ultimately deposed him, was his having attempted to banish all devils from the world. This absurd charge proceeded upon a complete misunderstanding of the whole gist and tenor of the work upon which it professes to be grounded. Dr Bekker does not deny the existence of the devil, as taught in Scripture, and is indeed most anxious to guard against such a construction being put upon his words, or such an inference deduced from his reasonings. The following passage, which is otherwise interesting, sets this in the clearest light:—"Ainsi la vérité de la Foy Chrétienne peut subsister, sans pourtant rien croire de la magie; ainsi moins l'on pense savoir ce que c'est que le diable, *à la reserve de ce que l'Ecriture nous en enseigne*, plus l'on peut connoître Dieu et Jesus Christ. Quand on ne connoit que Dieu, on en connoit assez; et toutes les connoissances qui sont hors de cet Etre Divin, ne sont que vanités et sottises." Scripture has declared that a knowledge of God is necessary to salvation; but it has nowhere said, so far as we remember, that, unless men know and believe in the devil, they will be damned. Dr Bekker, however, knew and believed all that the Scripture, rationally interpreted, warrants us to believe respecting the father of lies; and if his belief did not rise exactly to the pitch required by the demonologists of the Dutch synod, but, on the contrary, recoiled from their diabolical dogmas, it is precisely this inferiority of faith, conjoined with his manifest superiority of reason, which entitles him to the respect of all who can appreciate the honest boldness which enabled him to rise above the prejudices of his age, and to assail the abominations by which it was degraded and enslaved.

[2] Memoir on the Appearance of Spectres or Phantoms occasioned by Disease, with Psychological Remarks. Read by Nicolai to the Royal Society of Berlin on the 28th of February 1799. See a translation of this paper in *Nicolson's Journal*, vol. vi. p. 161.

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been derived from the subtile images of Epicurus. These, the reader will remember, were held by the Epicureans to be spontaneously exhaled or given off by all bodies; and, when they entered the mind, or, we should rather say, were impressed on the attenuated atoms or corpuscles, of the material soul, were supposed to generate spectral illusions. Rejecting the notion of exhalation, however, M. Meyer adhered to the spirit of this philosophy; contending that all our ideas are material, and that they are transported from unknown sources to the storehouse of the memory, through the medium of the organs of sense. Hence it was conceived, that the nerves upon which sensations depend might not only be affected by external agents, but impressed by internal causes, and that the result of this impression would be hallucinations or illusions. Thus, rays of light impressing the optic nerves from without might cause the sensation of yellow, while corrupt humours, as those of jaundice for instance, by impressing the nerves from within, might produce a similar effect. Further, as ideas were held to be material, and might be treasured up by the memory, it was conceived that they might, through some unknown channel, find their way to the nerves, and impress them after the manner of internal causes influencing the mind. "I shall suppose," says M. Meyer, "that I have lost a parent whom I loved, and whom I have seen and spoken to an infinity of times. Having perceived him often, I have consequently preserved the material figure and perception of him in the brain; for it is very possible and reconcilable to appearances, that a material figure, like that of my deceased friend, may be preserved for a long time in my brain, even after his death. By some intimate yet unknown relation, therefore, which the figure may have to my body, it may touch the optic or acoustic nerves. In the very moment, then, that my nerves are affected in the same manner that they formerly were when I saw or listened to my living friend, I shall be necessarily induced to believe that I really see or hear him, as if he were present."[1] This has certainly the merit of being *teres atque rotundus;* but, in the first place, it proceeds upon the assumed materiality of ideas, which, besides being abandoned by all philosophers, is an assumption that is far from being self-evident, and can never be proved; secondly, M. Meyer is forced at every step to take for granted some new principle, in regard to the re-action of these material ideas on the nervous system, that equally requires, without admitting of, proof; lastly, he ascribes to his ideas the functions performed by the imagination, and thus infuses an ingredient of truth which gives a colour of plausibility to his theory.

Dr Ferriar's *Theory of Apparitions*, as he has been pleased to call his very entertaining collection of ghost stories, is a complete misnomer, inasmuch as the book really contains no theory at all. "It is a well-known law," says he at the outset, "that the impressions produced on some of the external senses, especially on the eye, are more durable than the application of the impressing cause." It certainly required no ghost to tell us this; yet it is all that Dr Ferriar has vouchsafed to give us of a theoretical kind; "and," as Dr Hibbert pertinently remarks, "the brevity with which it is given is in exact conformity with the abruptness of its dismissal; for, after being applied to explain one or two cases only of mental illusions, numerous other instances of the kind are related, but the theory is not honoured with any further notice." Still the book is valuable as a collection of cases establishing the existence of morbid impressions, without any sensible external agency, and also as showing the power which the imagination possesses under particular circumstances, of re-acting upon the organs of sense with an intensity sufficient to create a temporary belief in the reality of the objects, the impressions of which are thus renovated and vivified.[2]

The work of Dr Hibbert, modestly entitled *Sketches of the Philosophy of Apparitions*, is of a different description from that of Dr Ferriar. In it a theory is distinctly propounded, and followed up through a vast complexity of details, which the theory is employed to explain and reconcile; and if the author had carried his generalization a step further, and at the same time paid more attention to the logical arrangement of his topics, he would have left little to be supplied by any future writer on this curious branch of the philosophy of the human mind. As it is, however, the book is full of interesting matter, and, what is of still greater importance, it furnishes ample materials for extending and enlarging the view of the subject, which the author has, upon the whole, so satisfactorily developed. After a not very skilful sketch of the opinions, ancient and modern, which have been entertained respecting apparitions, Dr Hibbert proceeds, in the *first* place, to consider the morbid affections with which the production of phantasms is often connected; 2*dly*, to show that the objects of spectral illusions are frequently suggested by the fantastic imagery of superstitious belief; 3*dly*, to investigate the mental laws which give rise to spectral illusions; 4*thly*, to notice the modifications which the intellectual faculty often undergoes during intense excitements of the mind; and, *lastly*, to state the comparative degrees of faintness, vividness, or intensity subsisting between sensations and ideas during their various excitements and depressions. And the general result at which he arrives, or, in other words, the law which connects and explains all the phenomena of apparitions, whether arising from morbid affections suggested by the fantastic imagery of superstition, or induced by certain states of the mind without any sensible extrinsic agency, is this, viz. "That apparitions are no-

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[1] *Essay on Apparitions*, attributed to M. Meyer, professor in the university of Halle, 1748.

[2] An anecdote is told by this author, which serves to illustrate the incidental observation in the text:—"A gentleman was benighted, while travelling alone, in a remote part of the Highlands of Scotland, and was compelled to ask shelter for the evening at a small lonely hut. When he was to be conducted to his bed-room, the landlady observed, with mysterious reluctance, that he would find the window very secure. On examination, part of the wall appeared to have been broken down to enlarge the opening. After some inquiry, he was told that a pedlar, who had lodged in the same room a short time before, had committed suicide, and was found hanging behind the door in the morning. According to the superstition of the country, it was deemed improper to remove the body through the door of the house; and to convey it through the window was impossible, without removing part of the wall. Some hints were dropped that the room had been subsequently haunted by the poor man's spirit. My friend laid his arms, properly prepared against intrusion of any kind, by the bed-side, and retired to rest, not without some degree of apprehension. He was visited in a dream by a frightful apparition, and, awaking in agony, found himself sitting up in bed, with a pistol grasped in his right hand. On casting a fearful glance round the room, he discovered, by the moonlight, a corpse dressed in a shroud, reared erect against the wall, close to the window. With much difficulty he summoned up resolution to approach the dismal object, the features of which, and the minutest parts of its funeral apparel, he perceived distinctly. He passed one hand over it, felt nothing, and staggered back to the bed. After a long interval, and much reasoning with himself, he renewed his investigation, and at length discovered that *the object of his terror was produced by the moon-beams forming a long bright image through the broken window*, on which his fancy, *impressed by his dream*, had pictured, with mischievous accuracy, the lineaments of a body prepared for interment. Powerful associations of terror, in this instance, had excited the recollected images with uncommon force and effect.

thing more than ideas, or the recollected images of the mind, which have been rendered as vivid as actual impressions;" a principle which, though somewhat incuriously expressed, makes, in our opinion, a very close approximation to the truth.

Dr Hibbert further conceives that the organs of sense are the actual medium through which past feelings are renovated; or, in other words, that when, from strong mental excitement, ideas have become as vivid as past impressions, or even more so, this intensity is induced by, or rather productive of, an absolute affection of those particular parts of the organic structure on which sensations depend; in the same way precisely as the salivary glands are known to be occasionally as much excited by the idea of some favourite food, as if the sapid body itself were actually present, stimulating the *papillæ* of the *fauces*. It would have been more simple and equally true if Dr Hibbert had said that the imagination, in some states, re-acts upon the organs of sense, and renovates past feelings or sensations, the natural antecedents of certain perceptions, with an intensity sufficient to create an illusion of reality; and this statement would have had the double advantage, of not only expressing, in a more generalized form, the important law of the human mind, which it is the object of all Dr Hibbert's investigations to evolve, but at the same time of excluding the particular views of physiology which are more or less mixed up with his metaphysical speculations. But the re-action in question may be either of a pleasurable kind or the reverse, according to the nature of the causes by which it is primarily produced; and as the mind can only exist in one state at an indivisible instant of time, it follows that when any agent, morbific or other, adds to the general vividness of our pleasurable feelings, those of an opposite or painful kind become proportionally less vivid, or rather are for the moment excluded; and, *vice versa*, the same law holds in regard to all our painful feelings, the increased intensity of which is necessarily accompanied with a corresponding abatement of those of an opposite kind. As the mind, however, passes from one state to another, or alternates between opposite states, with inconceivable rapidity, memory is sometimes apt to blend the recollected feelings of the one with those of the other, and thus to create a confusion in our conceptions of things which are in their own nature perfectly distinct. In some cases, where the nitrous oxide was administered, the patient, while under its influence, vibrated between perfect happiness and most consummate misery; but in the majority of instances the sensations produced were of a pleasurable description, to the exclusion of all those of an opposite kind; just as the sensations produced by an attack of the febrile miasma are almost invariably and exclusively those of the most acute pain. Hence the law above stated may be considered as a general one, when taken with the modifications proper to be applied to it. Lastly, Dr Hibbert has shown, that when mental feelings of any description attain a certain degree of vividness or intensity, muscular motions obey the impulse of the will, which is as much influenced by the re-acting and renovating power of imagination, as by any of our ordinary passions, appetites, or desires.

These principles, if we are not mistaken, go far to explain all the phenomena of dreams and apparitions; for the latter are merely waking dreams, and differ from the former in degree only, not in kind. In the case of Nicolai, which, as Dr Ferriar justly remarks, is one of the extreme instances of mental delusion which a man of strong judgment has ventured to report of himself, past impressions were renovated with the utmost accuracy and minuteness. The philosophical seer of Berlin beheld no "gorgons, hydras, and chimæras dire." The visions which he saw were neither terrible, ludicrous, nor repulsive; on the contrary, most of them were ordinary in their appearance, and some of them even agreeable. They were generally phantasms of his friends and acquaintance; or, in other words, exact copies of his past impressions and perceptions, so renovated and vivified as to create an illusion of reality, though for the most part oddly, if not grotesquely, put together. The story told so well by Dr Ferriar of the vision seen by the benighted gentleman who took up his quarters in the lonely Highland hut, is explicable on precisely the same principle; for his imagination, excited by his dream, pictured the corpse of the self-murdered pedlar behind the door by renovating and vivifying the mental images produced by the recital of the circumstances previously given to the traveller. In the cases of disease or superstition, again, the exciting causes are different, and the illusions generated consequently vary; but, in every instance where we can get at the circumstances, it will be found that these illusions or phantasms are merely vivid renovations of mental impressions previously received, and that, although the grouping may be fantastical, the ordinary laws of association are never transgressed.

Dr Brewster has remarked, as a physical fact, that "when the eye is not exposed to the impressions of external objects, or when it is insensible to these objects in consequence of being engrossed with its own operations, any object of mental contemplation, which has either been called up by the memory or created by the imagination, *will be seen as distinctly as if it had been formed from the vision of a real object.* In examining these mental impressions," he adds, "I have found that they follow the motions of the eye-ball exactly like the spectral impressions of luminous objects, and that they resemble them also in their apparent immobility when the eye-ball is displaced by an external force. If this result shall be found generally true by others, it will follow that the objects of mental contemplation *may be seen as distinctly as external objects*, and will occupy *the same local position in the axis of vision* as if they had been formed by the agency of light."[1] This goes to the very root of the theory of apparitions; all the phenomena of which seem to depend upon the relative intensities of the two classes of impressions, and upon the manner of their accidental combination. In perfect health, the mind not only possesses a control over its powers, but the impressions of external objects alone occupy its attention, and the play of imagination is consequently checked, except in sleep, when its operations are relatively more feeble and faint. But in the unhealthy state of the mind, when its attention is partly withdrawn from the contemplation of external objects, the impressions of its own creation, or rather reproduction, will either overpower or combine themselves with the impressions of external objects, and thus generate illusions which in the one case appear alone, while in the other they are seen projected among those external objects to which the eye-ball is directed, in the manner explained by Dr Brewster. We may add, that the same reasoning which applies to the impressions derived from the sense of sight, is equally applicable to those received

[1] See in the *Edinburgh Journal of Science*, conducted by Dr Brewster, a paper by the editor, entitled "Observations on the Vision of Impressions on the Retina, in reference to certain supposed Discoveries respecting Visions announced by Mr Charles Bell." Vol. ii. p. 1.

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through the medium of any other sense,—as the ear, for instance, an organ which ministers abundantly to the production of spectral illusions.

Again, with regard to those illusions, the objects of which are, according to this theory, suggested by the imagery of superstition, it is obvious that a belief in such imagery is calculated, in an ignorant and credulous age, to make a strong impression on the mind, and to imbue it deeply with all the peculiarities of the prevailing creed. In point of fact, there is nothing which men know so thoroughly, or remember so minutely, as superstitious legends, when this unearthly lore forms the subject of unquestioned and unquestionable belief. But all such impressions are more or less productive of and accompanied with fear; and hence when, from accidental circumstances, this passion happens to be excited to any degree of intensity, it not only withdraws the attention of the mind from the contemplation of external objects, but at the same time stimulates the imagination; which, again, reacts through the senses, vivifying mental images alone, or perhaps intermingling them, in fantastical combinations, with the impressions derived from external objects, and thus creating those spectral illusions which dreamers and seers in all ages have mistaken for realities. If the force of imagination alone can in some instances, without any sensible extrinsic agency, generate unreal mockeries and phantasms, much more must it do so when excited by a belief in supernatural agency, reinforced by fear, the most powerful of all the passions. "What brighter colours the fears of superstition give to the dim objects perceived in twilight, the inhabitants of the village," says Dr Thomas Brown, "who have to pass the churchyard at any late hour, and the little students of ballad-lore, who have carried with them, from the nursery, many tales which they almost tremble to remember, know well. And in the second sight[1] of this northern part of the island, there can be no doubt, that the objects which the seers conceive themselves to behold, are truly more vivid as conceptions, than, but for the superstitious and melancholy character of the natives, which harmonize with the objects of this foresight, they would have been; and that it is in consequence of this brightening effect of the emotion, as concurring with the dim and shadowy objects which the vapoury atmosphere of our lakes and valleys presents, that *fancy, relatively to the individual, becomes a temporary reality.* The gifted eye, which has once believed itself favoured with such a view of the future, will, of course, ever after have a quicker foresight, and more frequent revelations; its own wilder emotion communicating still more vivid forms and colours to the objects which it dimly perceives." In the case of such visions, however, there is often more of delusion in the seer, than of illusion in the phantasms which his "gifted eye" is supposed to have beheld; and hence the difficulty, as we have already remarked, or perhaps it would be more correct to say the impossibility, of explaining upon any one theory all the phenomena, as these have been detailed. But although it is inconsistent with the object of this article to diverge into illustrations in detail, we may be permitted to observe that all the narratives of spectral illusions which can be relied upon as deserving of credit, are perfectly explicable upon the principles here briefly but we trust intelligibly unfolded.

Having said thus much in reference to the theory of apparitions, it will not be necessary to enter at any length into that part of Sir Walter Scott's work on demonology and witchcraft[2] which relates to the present subject. Sir Walter has indeed attempted to sound the very depths of the philosophy of spectral illusion, and to account for their phenomena on known or admitted principles; but, with all possible respect and deference for this gifted writer, it may be doubted whether his line has reached the bottom, or afforded any just measure of its profundity. He has narrated, with a skill and effect peculiar to himself, a number of very striking cases,[3] and has connected these by a variety of observations, some of them not less remarkable for the

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[1] Most of the stories of second-sight told by the Highlanders seem arrant fabrications; and although we are by no means inclined to doubt the possibility of such illusions, any more than to question the fact, that they have sometimes accidentally coincided in point of time with events which seemed to give some confirmation to the belief in deuteroscopy, yet there is so much absurdity and imposture in nearly all the narratives of this kind which we have read, that we consider them utterly unworthy of serious consideration. The honest fellow who proposed to sell the secret for a pound of tobacco, knew more of the mysteries of second-sight than some grave philosophers. Dr John Macculloch has the following very pertinent remarks on the subject:—"To have circumnavigated the Western Isles without even mentioning the second-sight, would be unpardonable. No inhabitant of St Kilda pretends to have been forewarned of our arrival; ceasing to be believed, it has ceased to exist. It is indifferent whether the propagators of an imposture, or of a piece of supernatural philosophy, be punished or rewarded. In either case the public attention is directed towards the agent; whether by the burning of the witch, or by the flattering distinction which attended the Highland seer. When witches were no longer burned, witchcraft disappeared. Since the second-sight has been limited to a doting old man, or a hypochondriacal tailor, it has been a subject for ridicule; and in matters of this nature ridicule is death." (*Description of the Western Isles*, by John Macculloch, M. D. vol. ii. p. 32.) While the world believed in the second-sight and in witchcraft, there never failed to be seers and witches. The supposed possession of these faculties insured notoriety, flattered vanity, conferred power, and afforded the means of gratifying malice: And what will not men and women do to attain distinctions and advantages like these? The vain will covet them, the ambitious will grasp at them, the malicious, if otherwise helpless and spited at the world, will run all risks, both here and hereafter, to secure them. Hence the enormous impostures of witchcraft, and hence also delusions as hideous as the knavery was gross and revolting. This is the true key to the solution of a vast number of cases which, it has been supposed, we can neither believe, account for, nor refute. But the misfortune is, that most of those who have written on the subject have had more faith than philosophy, and more fancy than faith, in consequence of which they have jumbled truth and falsehood together in such wild confusion, that all the alchemy of logic is insufficient to resolve the compound into its constituent elements, and separate the one from the other.

[2] *Letters on Demonology and Witchcraft*, addressed to J. G. Lockhart, Esq. By Sir Walter Scott, Bart.

[3] The following is one of the *most* striking, and although the narrative be long, it will be found exceedingly interesting:—"A second, and equally remarkable instance, was communicated to the author by the medical man under whose observation it fell, but who was, of course, desirous to keep private the name of the hero of so singular a history. Of the friend by whom the facts were attested, I can only say, that if I found myself at liberty to name him, the rank which he holds in his profession, as well as his attainments in science and philosophy, form an undisputed claim to the most implicit credit.

"It was the fortune of this gentleman to be called in to attend the illness of a person now long deceased, who in his lifetime stood, as I understand, high in a particular department of the law, which often placed the property of others at his discretion and control, and whose conduct, therefore, being open to public observation, he had for many years borne the character of a man of unusual steadiness, good sense, and integrity. He was, at the time of my friend's visits, confined principally to his sick-room, sometimes to bed, yet occasionally attending to business, and exerting his mind, apparently with all its usual strength and energy, to the conduct of important affairs intrusted to him; nor did there, to a superficial observer, appear any thing in his conduct, while so engaged, that could argue vacillation of intellect or depression of mind. His outward symptoms of malady argued no acute or alarming disease. But slowness of pulse, absence of appetite, difficulty of digestion, and constant depression of spirits, seemed to draw their origin from

acuteness they display, than for the very great felicity with which they are expressed. But even with Dr Hibbert's work as a guide, and all the collateral lights which have been thrown upon the subject by the researches of

some hidden cause, which the patient was determined to conceal. The deep gloom of the unfortunate gentleman—the embarrassment, which he could not conceal from his friendly physician—the briefness and obvious constraint with which he answered the interrogations of his medical adviser—induced my friend to take other methods for prosecuting his enquiries. He applied to the sufferer's family, to learn, if possible, the source of that secret grief which was gnawing the heart and sucking the life-blood of his unfortunate patient. The persons applied to, after conversing together previously, denied all knowledge of any cause for the burden which obviously affected their relative. So far as they knew—and they thought they could hardly be deceived—his worldly affairs were prosperous; no family loss had occurred which could be followed with such persevering distress; no entanglements of affection could be supposed to apply to his age, and no sensation of severe remorse could be consistent with his character. The medical gentleman had finally recourse to serious argument with the invalid himself, and urged to him the folly of devoting himself to a lingering and melancholy death, rather than tell the subject of affliction which was thus wasting him. He specially pressed upon him the injury which he was doing to his own character, by suffering it to be inferred that the secret cause of his dejection, and its consequences, was something too scandalous or flagitious to be made known, bequeathing in this manner to his family a suspected and dishonoured name, and leaving a memory with which might be associated the idea of guilt, which the criminal had died without confessing. The patient, more moved by this species of appeal than by any which had yet been urged, expressed his desire to speak out frankly to Dr ———. Every one else was removed, and the door of the sick-room made secure, when he began his confession in the following manner:—

"'You cannot, my dear friend, be more conscious than I, that I am in the course of dying under the oppression of the fatal disease which consumes my vital powers; but neither can you understand the nature of my complaint, and the manner in which it acts upon me; nor, if you did, I fear, could your zeal and skill avail to rid me of it.'—'It is possible,' said the physician, 'that my skill may not equal my wish of serving you; yet medical science has many resources, of which those unacquainted with its powers never can form an estimate. But until you plainly tell me your symptoms of complaint, it is impossible for either of us to say what may or may not be in my power, or within that of medicine.'—'I may answer you,' replied the patient, 'that my case is not a singular one, since we read of it in the famous novel of Le Sage. You remember, doubtless, the disease of which the Duke d'Olivarez is there stated to have died?'—'Of the idea,' answered the medical gentleman, 'that he was haunted by an apparition, to the actual existence of which he gave no credit, but died, nevertheless, because he was overcome and heart-broken by its imaginary presence.'—'I, my dearest Doctor,' said the sick man, 'am in that very case; and so painful and abhorrent is the presence of the persecuting vision, that my reason is totally inadequate to combat the effects of my morbid imagination, and I am sensible I am dying, a wasted victim to an imaginary disease.' The medical gentleman listened with anxiety to his patient's statement, and for the present judiciously avoiding any contradiction of the sick man's preconceived fancy, contented himself with more minute enquiry into the nature of the apparition with which he conceived himself haunted, and into the history of the mode by which so singular a disease had made itself master of his imagination, secured, as it seemed, by strong powers of the understanding, against an attack so irregular. The sick person replied by stating, that its advances were gradual, and at first not of a terrible or even disagreeable character. To illustrate this, he gave the following account of the progress of his disease.

"'My visions,' he said, 'commenced two or three years since, when I found myself from time to time embarrassed by the presence of a large cat, which came and disappeared I could not exactly tell how, till the truth was finally forced upon me, and I was compelled to regard it as no domestic household cat, but as a bubble of the elements, which had no existence save in my deranged visual organs or depraved imagination. Still I had not that positive objection to the animal entertained by a late gallant Highland chieftain, who has been seen to change to all the colours of his own plaid if a cat by accident happened to be in the room with him, even though he did not see it. On the contrary, I am rather a friend to cats, and endured with so much equanimity the presence of my imaginary attendant, that it had become almost indifferent to me; when within the course of a few months it gave place to, or was succeeded by, a spectre of a more important sort, or which at least had a more imposing appearance. This was no other than the apparition of a gentleman-usher, dressed as if to wait upon a lord-lieutenant of Ireland, a lord high commissioner of the kirk, or any other who bears on his brow the rank and stamp of delegated sovereignty.

"'This personage, arrayed in a court dress, with bag and sword, tamboured waistcoat, and *chapeau-bras*, glided beside me like the ghost of Beau Nash; and, whether in my own house or in another, ascended the stairs before me, as if to announce me in the drawing-room; and at some times appeared to mingle with the company, though it was sufficiently evident that they were not aware of his presence, and that I alone was sensible of the visionary honours which this imaginary being seemed desirous to render me. This freak of the fancy did not produce much impression on me, though it led me to entertain doubts on the nature of my disorder, and alarm for the effect it might produce upon my intellects. But that modification of my disease also had its appointed duration. After a few months the phantom of the gentleman-usher was seen no more, but was succeeded by one horrible to the sight and distressing to the imagination, being no other than the image of death itself—the apparition of a *skeleton*. Alone or in company,' said the unfortunate invalid, 'the presence of this last phantom never quits me. I in vain tell myself a hundred times over that it is no reality, but merely an image summoned up by the morbid acuteness of my own excited imagination and deranged organs of sight. But what avail such reflections, while the emblem at once and presage of mortality is before my eyes, and while I feel myself, though in fancy only, the companion of a phantom representing a ghastly inhabitant of the grave, even while I yet breathe on the earth? Science, philosophy, even religion, has no cure for such a disorder; and I feel too surely that I shall die the victim to so melancholy a disease, although I have no belief whatever in the reality of the phantom which it places before me.'

"The physician was distressed to perceive, from these details, how strongly this visionary apparition was fixed in the imagination of his patient. He ingeniously urged the sick man, who was then in bed, with questions concerning the circumstances of the phantom's appearance, trusting he might lead him, as a sensible man, into such contradictions and inconsistencies as might bring his common sense, which seemed to be unimpaired, so strongly into the field, as might combat successfully the fantastic disorder which produced such fatal effects. 'This skeleton, then,' said the Doctor, 'seems to you to be always present to your eyes?'—'It is my fate, unhappily,' answered the invalid, 'always to see it.'—'Then I understand,' continued the physician, 'it is now present to your imagination?'—'To my imagination it certainly is so,' replied the sick man.—'And in what part of the chamber do you now conceive the apparition to appear?' the physician enquired. 'Immediately at the foot of my bed; when the curtains are left a little open,' answered the invalid, 'the skeleton, to my thinking, is placed between them, and fills the vacant space.'—'You say you are sensible of the delusion,' said his friend; 'have you firmness to convince yourself of the truth of this? Can you take courage enough to rise and place yourself in the spot so seeming to be occupied, and convince yourself of the illusion?' The poor man sighed, and shook his head negatively. 'Well,' said the Doctor, 'we will try the experiment otherwise.' Accordingly, he rose from his chair by the bedside, and placing himself between the two half-drawn curtains at the foot of the bed, indicated as the place occupied by the apparition, asked if the spectre was still visible? 'Not entirely so,' replied the patient, 'because your person is betwixt him and me; but I observe his skull peering above your shoulder.'

"It is alleged the man of science started on the instant, despite philosophy, on receiving an answer ascertaining, with such minuteness, that the ideal spectre was close to his own person. He resorted to other means of investigation and cure, but with equally indifferent success. The patient sunk into deeper and deeper dejection, and died in the same distress of mind in which he had spent the latter months of his life; and his case remains a melancholy instance of the power of imagination to kill the body, even when its fantastic terrors cannot overcome the intellect, of the unfortunate persons who suffer under them. The patient, in the present case, sunk under his malady; and the circumstances of his singular disorder remaining concealed, he did not, by his death and last illness, lose any of the well-merited reputation for prudence and sagacity which had attended him during the whole course of his life."

Apparitions.

Dr Ferriar, Dr Brewster, and others, Sir Walter has failed to reach any general principle applicable to a given class of cases. The consequence is, that, although his observations are almost always valuable, and often involve the very law which connects and explains the phenomena of spectral illusion, he constantly stops short on the verge of the discovery, and is therefore under the necessity of seeking a new explanation of each successive case, which is, for the most part, considered separately and without reference to or comparison with others. On several occasions, indeed, he attempts to generalize, and makes very close approximations to the truth; but, like those tuneless persons who sometimes essay good-naturedly to sing, and stumble about the outskirts of an air, without ever being able to hit it exactly, Sir Walter frequently comes so very near the point he aims at, that we are surprised how he should miss it.

This is singularly exemplified in the following observations, which, with reference to the view we have now taken, are exceedingly important:—"Enthusiastic feelings of an impressive and solemn nature," says Sir Walter, "occur both in private and public life, which seem to add ocular testimony to an intercourse betwixt earth and the world beyond it. For example, the son who has been lately deprived of his father feels a sudden crisis approach, in which he is anxious to have recourse to his sagacious advice—or a bereaved husband earnestly desires again to behold the form of which the grave has deprived him for ever—or, to use a darker yet very common instance, the wretched man who has dipped his hand in his fellow-creature's blood, is haunted by the apprehension that the phantom of the slain stands by the bedside of his murderer. In all, or any of these cases, who shall doubt that *imagination*, favoured by circumstances, *has power to summon up to the organ of sight spectres which only exist in the mind of those by whom their apparition seems to be witnessed?* If we add, that such a vision may take place in the course of one of those lively dreams in which the patient, except in respect to the single subject of *one* strong impression, is or seems sensible of the real particulars of the scene around him, a state of slumber which often occurs—if he is so far conscious, for example, as to know that he is lying on his own bed, and surrounded by his own familiar furniture, at the time when the supposed apparition is manifested, it becomes almost in vain to argue with the visionary against the reality of his dream, since the spectre, though itself purely fanciful, *is inserted* amidst so many circumstances which he feels must be true beyond the reach of doubt or question. That which is undeniably certain becomes in a manner a warrant for the reality of the appearance to which doubt would have been otherwise attached. And if any event, such as the death of the person dreamt of, *chances to take place*, so as to correspond with the nature and the time of the apparition, *the coincidence*, though one which must be frequent, since our dreams usually refer to the accomplishment of that which haunts our minds when awake, and often presage the most probable events, seems perfect, and the chain of circumstances touching the evidence may not unreasonably be considered as complete."

Now, it must be obvious to every one, that the true theory of apparitions is involved in these observations, though not unfolded in such a manner as to render it available for the explanation of spectral illusions. The author distinctly indicates, in the first place, the power of imagination, when excited, "to summon up to the organ of sight spectres which only exist in the mind of those by whom their apparition seems to be witnessed," or, in other words, to reproduce past impressions through the medium of the senses; and, secondly, in certain kinds of *dreams*, he recognises the principle, which Dr Brewster has shown to hold good in our waking hours, that "the objects of mental contemplation may be seen as distinctly as external objects, and will occupy the same local position in the axis of vision, as if they had been formed by the agency of light;" while their being "inserted" amidst so many objects in regard to which there is no deception, will at the same time contribute to strengthen the illusion of reality, and to render the visionary inaccessible to any arguments tending to call it in question. But no use whatever is made of these important principles; which, so far from being pushed to their consequences, and thus disencumbered of the limitations which the author has assigned to them, are stated apparently for no other reason than that they may be straightway cast aside and forgotten.

Another example may be given of this unavailing approximation to the truth, on a most important branch of the subject. That disordered or excited state of the imagination arising from morbific causes, in which it re-acts upon the organs of sense, and generates spectral illusions, "is not," he thinks, "properly insanity, although it is somewhat allied to that most horrible of maladies, and may, in many constitutions, be the means of bringing it on, and although such hallucinations are proper to both." The difference he conceives to be, that "in cases of insanity, the mind of the patient is principally affected, while the senses or organic system offer in vain to the lunatic their decided testimony against the phantasy of a diseased imagination." There is some confusion here, both in conception and expression; but still the author is correct in his general idea, however vaguely indicated, that the difference he alludes to is one of degree rather than of kind. A few observations will, we think, make this abundantly evident, and at the same time show in how remarkable a manner the phenomena of insanity, viewed in reference to the subject before us, illustrate that reflective or renovating power of the imagination to which alone we ascribe the production of phantasms and spectres.

The history of this malady (says Pinel) claims alliance with all the errors and delusions of superstitious credulity—with those of witchcraft, demoniacal possession, oracles, divinations, and spectral illusions; and hence he considers it as eminently deserving of attention, on the part of the mental, as well as on that of the medical philosopher who may be called upon practically to minister consolation and relief to minds diseased. Insanity, considered generally, is merely the excess of that state or of those states of the mind during which hallucinations are produced; and this excess, when prolonged beyond a certain limit, terminates in fatuity, or the complete exhaustion and paralysis of the mental powers, just as bodily exertion, when urged beyond a certain pitch (varying, however, in each individual), terminates in the suspension of all physical energy, and ultimately in death. In both cases nature has provided a restorative power, which, up to a definitive point, can repair the injury produced by excited action, and enable the mind and body to recover their wonted tone and health; but if the excitation continue, or be pushed beyond this limit, the restorative efficacy is destroyed, and neither can ever regain their former condition. It is this excess alone which, in the case of mind, constitutes insanity. It is the unnatural continuance or prolongation of excited action which ultimately overwhelms the whole mental powers; not even excepting the imagination itself, the very instrument, if we may so express it, by which this melancholy ruin is accomplished. Hence it is commonly observed that persons endowed with the greatest susceptibility of mental excitement, with the warmest passions, the most active imaginations, and the most acute sensibilities, evince the strongest pre-

disposition to insanity; and as this is the temperament that usually accompanies genius, every one can easily appreciate the truth of the observation which a celebrated poet has consecrated in his numbers, that great wit is nearly allied to madness, and that "thin partitions do the bounds divide" which separate the one from the other. But this predisposing temperament, of which genius is a natural product, and insanity the excess or diseased state, is also that which renders men peculiarly susceptible of superstitious impressions, and upon which these, when once received into the mind, and treasured up in the memory, are likely, through the medium of the imagination, to re-act with the greatest force, and thus to give a sort of reflex impulse to the temperament which predisposes towards their reception. Need we wonder, then, to find the imagery of superstition so frequently blended and mixed up with the wild delusions of insanity, or the one acting upon and aggravating all the symptoms of the other? Need we wonder that in a great variety of instances superstition should become the exciting cause of insanity, or that the visions of insanity should, in their turn, form new objects of superstition?

In all cases of mental excitement, howsoever produced, the results may vary in proportion to the relative intensity of the excited action; but on a close examination it will be found that the difference observable amongst them is a difference of degree only, not of kind. "From recalling images by an act of the memory," says Dr Ferriar, "the transition is direct to beholding spectral objects which have been floating in the imagination;" and he adds that he has frequently, in the course of his professional practice, conversed with persons who imagined they saw demons, and heard them speak; a species of delusion which, he thinks, admits of many gradations and distinctions exclusive of actual insanity. Sir Walter Scott also mentions the case of a patient similarly affected, who, being troubled with a diurnal vision of an unsightly hag, consulted the late Dr Gregory on the subject of this visitation, but, as appears from the narrative, without deriving any material benefit from the skill of that eminent and learned physician. As the spectre was very regular in its appearance, and always visited the patient at a stated hour, the doctor, on one occasion, exerted all his powers of conversation, which were very great, to engage the mind of this individual, and if possible beguile him into a forgetfulness of time, that the awful hour might pass unobserved—but, as it turned out, without effect; for scarcely had the clock struck the hour, when the patient screamed out that he beheld the apparition. Ordinary impressions, indeed, are never sufficient to control such as are produced by an imagination excited as this man's must have been. Hence, finding his expedient vain, Dr Gregory had recourse to his usual remedy of blood-letting, in order to relieve the plethoric or apoplectic affection under which he concluded that the patient must be labouring; but whether this antiphlogistic treatment had the effect of dismissing the phantom hag who had previously repeated her visits so regularly, Sir Walter has not informed us. Delusions of this sort, as Dr Ferriar observes, certainly admit of gradations short of actual insanity; but the difference, as we have already remarked, is one of degree only, not of kind; for, in all such cases, a little additional intensity of excitement is only wanting to deprive the mind of that power over its impressions generally which it has already lost over one set, and thus to overwhelm it at once under a hideous mass of morbid hallucinations. The same observation is applicable to the partial illusions generated by hysteria, hypochondria, febrile affections, inflammations of the brain, *delirium tremens*, and other diseases which exert a disturbing influence over the nervous system, especially that part of it more immediately connected with sensation. The exciting causes may vary, and the particular illusions created may partake of this variation; yet it will be found that, the excitement once produced, the resulting phenomena observe invariably the same law, and that according as the degree of that excitement is greater or less, so will the morbid affection of the mind either amount to actual insanity, or fall short of it by some gradations. The true theory of apparitions, therefore, is essentially the same with that of insanity; nor, in determining the general principle which connects the one class of phenomena, can we fail, if we pursue the proper course of investigation, to ascertain that which regulates and consequently explains the other.[1]

These observations, as the reader must have already perceived, apply only to that part of Sir Walter Scott's work which relates to apparitions, and which, in fact, is greatly inferior in interest as well as importance to the masterly exposition he has given of the various systems of magic and demonology which have prevailed at different times and in different countries. Here he is evidently quite at home; and as his treasures of ghostly lore are unbounded, his judicious observations are continually illustrated by the most apposite and striking narratives, frequently derived from sources which are not generally accessible. His remarks on the denunciation against witches contained in the Old Testament, as well as on the particular case of the sorceress of Endor, consulted by Saul, are exceedingly interesting; and we think the distinction he has drawn between Jewish witchcraft, which was connected with the abominations of idolatry, and that of modern times, which was the joint product of ignorance, credulity, fear, persecution, and imposture, perfectly sound. That the witch of Endor was a mere fortune-teller, to whom the unfortunate king of Israel had recourse in his despair, is beyond all question or doubt; and the only difficulty is to explain how it was so ordained that the spirit of the prophet Samuel should arise amidst the incantations of an impostor, and thus lend a

[1] The activity which the soul frequently displays during sleep, or, in other words, the phenomena of dreams, engaged the attention of metaphysicians at an early period, and gave rise to numerous learned and ingenious speculations, an exquisite summary of which, accompanied with many truly refined and subtile observations of his own, the reader will find in the chapter where Mr Dugald Stewart treats of this subject in his *Elements of the Philosophy of the Human Mind*. "Dreams," says Mr Addison, "look like the relaxations and amusements of the soul when she is disencumbered of her machine; her sports and recreations when she has laid her charge asleep. The soul is clogged and retarded in her operations when she acts in conjunction with a companion that is so heavy and unwieldy in its motions; but in dreams she converses with numberless beings of her own creation, and is transported into ten thousand scenes of her own raising. She is herself the theatre, the actor, and the beholder." This is finely said, and not more beautiful than true. But the reader will not fail to observe, that as Mr Addison's description, if somewhat heightened in its colouring and distorted in its features, would apply to insanity as well as to dreams, so the state of the soul which produces the one would, if highly excited, exhibit all the characteristic phenomena of the other. Dreams, indeed, are but faint adumbrations of that vivid phantasmagoria which madness presents to the eye of the mind, and which is also accompanied with an increased intensity in all the feelings and emotions of the soul, whether connected with the predominant hallucination, or otherwise. Hence Pinel has remarked, that, even during the intervals of comparative calmness and reason, he has nowhere met, except in romance, with fonder husbands, more affectionate parents, more impassioned lovers, or purer and more exalted patriots, than in an asylum for lunatics.

sort of countenance to the belief in magical charms and divinations, which was already but too generally and deeply rooted in the minds of the Israelites. This, however, is not the place to enter into the discussion of matters which properly fall to be treated of under different heads, and which involve principles totally different from those which are applicable to the case of apparitions alone. (A.)

APPARITOR, among the Romans, a general term to comprehend all attendants of judges and magistrates appointed to receive and execute their orders. *Apparitor*, in England, is a messenger that serves the process of a spiritual court, or a beadle in a university who carries the mace.

APPAUMEE, in *Heraldry*, denotes one hand extended with the full palm appearing, and the thumb and fingers at full length.

APPEAL, in *Law*, the removal of a cause from an inferior to a superior court or judge, when a person thinks himself aggrieved by the sentence of the inferior judge. Appeals lie from the ordinary courts of justice to the house of lords. In ecclesiastical cases, if an appeal is brought before a bishop, it may be removed to the archbishop; if before an archdeacon, to the court of arches, and thence to the archbishop; and from the archbishop's court to the king in chancery.

APPELLATION, the name by which any thing is known or distinguished when spoken of. Nothing can be more foreign to the original meaning of many words and proper names than their present or vulgar appellations; frequently owing to the history of those things being forgotten, or an ignorance of the language in which they were expressed. Who, for example, would dream that the legal proclamation called "O yes," was a proclamation commanding the talkers to become hearers, being the French word *Oyez*, listen, retained in our courts ever since the law pleadings were held in French? Or would any person suppose that the headland on the French coast near Calais, called by our seamen Blackness, would be so titled from its French name of *Blanc Nez*, or the *White Head-land?*

King Henry the Eighth having taken the town of Boulogne in France, the gates of which he brought to Hardes in Kent, where they are still remaining, the flatterers of that reign highly magnified this action, which, Porto Bello like, became a popular subject for signs; and the port or harbour of Boulogne, called *Boulogne Mouth*, was accordingly set up at a noted inn in Holborn. The name of the inn long outliving the sign and fame of the conquest, an ignorant painter, employed by a no less ignorant landlord to paint a new one, represented it by a bull and a large gaping human mouth; answering to the vulgar pronunciation of *bull and mouth*. The same piece of history gave being to the *bull and gate*, originally meant for Boulogne gate, and represented by an embattled gate or entrance into a fortified town.

The *barber's pole* has been the subject of many conjectures; some conceiving it to have originated from the word *poll* or head, with several other conceits as far-fetched and as unmeaning; but the true intention of that party-coloured staff was to show that the master of the shop practised surgery, and could breathe a vein as well as mow a beard. The white band which encompasses the staff was meant to represent the fillet thus elegantly twined about it.

Nor were the *chequers*, at this time a common sign of a public house, less expressive,—being the representation of a kind of draught-board called *tables*, and showing that there that game might be played. From their colour, which was red, and the similarity to a lattice, it was corruptly called the *red lettuce*, which word is frequently used by ancient writers to signify an ale-house.

The *Spectator* has explained the sign of the *bell-savage inn* plausibly enough, in supposing it to have been originally the figure of a beautiful female found in the woods, called in French *la belle sauvage*. But another reason has since been assigned for that appellation, namely, that the inn was once the property of Lady Arabella Savage, and familiarly called *Bell Savage's Inn*, probably represented, as at present, by a bell and a savage or wild man, which was a rebus for her name; rebuses being much in fashion in the 16th century.

The *three blue balls* prefixed to the doors and windows of pawnbrokers' shops, by the vulgar humorously enough said to indicate that it is two to one that the things pledged are never redeemed, were in reality the arms of a set of merchants from Lombardy, who were the first that publicly lent money on pledges. They dwelt together in a street, from them named Lombard Street, in London, and also gave their name to another at Paris. The appellation of Lombard was formerly all over Europe considered as synonymous with that of usurer.

At the institution of yeomen of the guards, they used to wait at table on all great solemnities, and were ranged near the buffets. This procured them the name of *buffetiers*, not very unlike in sound to the jocular appellation of *beef-eaters*, now given them; though probably it was rather the voluntary misnomer of some wit, than an accidental corruption arising from ignorance of the French language.

The opprobrious title of *bum bayliffe*, so constantly bestowed on the sheriff's officers, is, according to Judge Blackstone, only the corruption of *bound bayliffe*, every sheriff's officer being obliged to enter into bonds and to give security for his good behaviour, previous to his appointment.

A *cordwainer* seems to have no relation to the occupation it is meant to express, which is that of a shoemaker. But *cordonier*, originally spelt *cordaunier*, is the French word for that trade; the best leather used for shoes coming originally from Cordova in Spain.

APPELLATIVE NAMES, in *Grammar*, in contradistinction to proper names, are such as stand for universal ideas, or a whole rank of beings, whether general or special. Thus, *fish, bird, man, city, river*, are common or appellative names; and so are *trout, eel, lobster;* for they all agree to many individuals, and some to many species.

APPENZELL, one of the cantons of Switzerland. It is a mountainous district, surrounded by the canton of St Gall. Three chains of hills, continuations of the Alps, with valleys between them, form the chief part of the surface. The highest point of the hills is 7671 feet. In these are some extraordinary natural excavations, particularly the Ziegerloch and the Wildkirchlein. The climate is raw and cold, little calculated for agriculture, but adapted in some degree for breeding cattle, and for the dairy. The extent has been variously reported: it is probably about 220 square miles. The number of inhabitants, by the last estimate, is about 58,000, who are divided into 22 communes or parishes. The outer part of the canton was occupied by manufacturers of cotton and linen goods, and by calico printers; but of late years these fabrics have declined, and much distress has followed. The poverty thus produced has led to extensive emigrations to the western world. The constitution is a pure

democracy, each individual above 16 years having a vote. About one third of the inhabitants are Catholics, the remainder Protestants of the Calvinistic confession. The canton is formed into two divisions, each with its respective capital: Herisau is the capital of the outer division, and Appenzell of the inner.

Appenzell, a city, the capital of the inner division of the canton of that name in Switzerland. It stands on the river Sitter, in a beautiful valley. It contains one church of Gothic architecture, a capuchin monastery, a nunnery, with several chapels, and about 3000 inhabitants, who chiefly subsist by linen weaving and bleaching.

APPETITE, in a general sense, the desire of enjoying some object, supposed to be conducive to our happiness. This term is applied particularly to hunger, thirst, and the appetite of sex. Considered as principles of action, the appetites are distinguished by the following circumstances:—1. They take their rise from the body, and are common to us with the brutes. 2. They are not constant, but occasional. 3. They are accompanied with an uneasy sensation, which is strong or weak in proportion to the strength or weakness of the appetite. See Stewart's *Philosophy of the Active Powers*, book i. chap. i.

APPIA Via, a way reaching from Rome through Capua to Brundusium, between 330 and 350 miles long. Appius Claudius, surnamed *Cæcus*, in the year of the city 441, carried it from the Porta Capena to Capua. (Livy, Frontinus.) It was afterwards carried on to Brundusium, but by whom, or when, is uncertain. It was laid with very hard stone, brought from a great distance, large, and squared (Diodorus); and it was so wide that several waggons could go abreast. Statius calls it *the queen of roads*. Its course is described by Horace, Strabo, and Antonine.

APPIAN, an eminent writer of the Roman history in Greek, under the reigns of Trajan and Adrian. He was of a good family in Alexandria in Egypt; whence he went to Rome, and there distinguished himself so well as an advocate, that he was chosen one of the procurators of the empire, and the government of a province was committed to him. He did not complete the Roman history in a continued series, but wrote distinct histories of all nations that had been conquered by the Romans, in which he placed every thing relating to those nations in the proper order of time. Of all this voluminous work there remains only what treats of the Punic, Syrian, Parthian, Mithridatic, and Spanish wars, with those against Hannibal, the civil wars, and the wars in Illyricum, and some fragments of the Celtic or Gallic wars. An excellent edition of Appian was published by Schweighæuser in Greek and Latin, at Leipsic, in 1785, in 3 vols. 8vo. The extracts from the lost books, preserved by various authors, have been collected in this edition.

APPIUS Claudius, a Sabine by birth, one of the principal inhabitants of Regillum. His shining merit having drawn the envy of his fellow-citizens upon him, he retired to Rome with all his family. Appius was admitted into the senate, and was made consul with Publius Servilius Priscus in 258 from the building of Rome; but he was hated by the plebeians, being an austere opposer of their clamours and seditions. The Claudian family continued long one of the most illustrious of the patrician families in Rome, and several in succession of the name of Appius supported the same stern character that distinguished their first founder.

APPLAUSE, an approbation of something, signified by clapping the hands, still practised in theatres. Applause, in antiquity, differed from acclamation, as the latter was articulate and performed with the voice, the former with the hands. Among the Romans, applause was an artificial kind of noise made by the audience or spectators to express their satisfaction. There were three species of applause, denominated from the different noises made in them, viz. *Bombus*, *Imbrices*, and *Testæ*; the first a confused din, made either by the hands or the mouth; the second and third, by beating on a sort of sounding vessels placed in the theatres for this purpose. Persons were instructed to give applause with skill; and there were even masters who professed to teach the art. The proficients in this way let themselves out for hire to the vain-glorious among the poets, actors, &c., and were properly disposed to support a loud applause. These they called *Laudicœni*, and Σοφοκλεις. At the end of the play a loud peal of applause was expected, and even asked of the audience, either by the chorus or the persons who spoke last. The formula was *Spectatores plaudite*, or *Valete et plaudite*. The plausores or applauders were divided into chori, and disposed in theatres opposite to each other, like the choristers in cathedrals, so that there was a kind of concert of applauses.

APPLE. See Horticulture.

APPLEBY, a small market and borough town in the county of Westmoreland, 269 miles from London, 14 from Penrith, and 32 from Carlisle. It is on the river Eden, which nearly surrounds it. The assizes and the election of county members are held here. It returns two members to parliament. There is a corn market held on Saturday. The population in 1801 was 711; in 1811, 815; and in 1821, 999.

APPLICATION, in a general sense, is the laying of two things together, in order to discover their agreement or disagreement.

Application, in *Geometry*, is used either for division; for applying one quantity to another, whose areas, but not figure, shall be the same; or for transferring a given line into a circle or other figure, so that its ends shall be in the perimeter of the figure.

Application, in *Theology*, is particularly used by some divines for the act whereby our Saviour transfers or makes over to us what he had earned or purchased by his holy life and death. Accordingly it is by this application of the merits of Christ that we are to be justified and entitled to grace and glory. The sacraments are the ordinary means or instruments whereby this application is effected.

APPOLLONIA, a considerable kingdom in Africa, about 100 miles in length, situated on the Gold Coast, from the western extremity of which it extends to the river Ancobra. The territory being intersected by numerous small streams which overflow their banks during the rainy season, is very well adapted for the growth of rice and the sugar-cane. The coast affords neither harbour nor creek; but goods are conveyed on shore in canoes, which are managed by the natives with great dexterity. The government is monarchical; the people are honest, courteous, and hospitable; and the trader, in dealing with them, finds his person and property quite secure. The ports are Appollonia, Assinee, Great and Little Bassam; at each of which may be obtained gold and ivory, the former of rather superior quality. The British had formerly a fort at Appollonia, which they have now withdrawn.

APPOLONIA, a town of Austrian Italy, in the delegation of Brescia, in the government of Venetian Lombardy. It is in a lofty situation, and contains 1386 inhabitants, who are mostly employed in making gun-locks, bayonets, swords, and other implements of war.

APPOSITION, in *Grammar*, the placing of two or more substantives together, in the same case, without any copulative conjunction between them; as *Ardebat Alexim, delicias domini*.

APPRAISER (from *ad*, to, and *pretium*, value), one who rates or sets a value upon goods, &c. He must be

a skilful and honest person. It is not a business of itself, but is practised by brokers of household furniture, to which set of men the word is chiefly applied; yet upholsterers and other brokers are employed, or even any person or persons who are supposed to be skilled in the commodities to be appraised or valued.

APPREHENSION, in *Logic*, denotes the simple attention of the mind to an object presented either to our sense or our imagination, without passing a judgment or making an inference.

APPREHENSION, in *Law*, signifies the seizing of a criminal in order to bring him to justice.

APPRENTICE (from *apprendre*, to learn), one who is bound by covenant to serve a tradesman or artificer a certain time, upon condition of the master's instructing him in his art or mystery.

By the common law, every person is left at liberty to follow whatever trade or employment may be agreeable to him. But as it was supposed that great injury would result to the public if unqualified persons were to exercise the various crafts and mysteries connected with the mechanical trades, it was specially provided, by the 5th Eliz., that no person should exercise any art or craft unless he had previously qualified himself for it by a regular apprenticeship, under a penalty of L.400 for every month. Considerable doubts were always entertained as to the trades to which this statute applied; and as the courts of law do not seem generally to have favoured the principle of the statute, their decisions tended rather to confine than to extend the restriction. It was at length agreed that the law was only applicable to such trades as existed at the time of passing the act, and to such also as implied some mystery or craft. The operation of the statute was also held to be limited to market-towns, it being supposed necessary for the convenience of the inhabitants of country villages, that the same person should exercise different trades, even though he had not been regularly bred by a seven years' apprenticeship to each. These various limitations of the statute gave rise to many very absurd distinctions, which plainly showed how very unsuitable this antiquated law was to the present advanced state of the mechanical trades. It was found, for example, that a coachmaker could neither himself make nor employ journeymen to make his coach-wheels, but that it behoved him to buy them of a master wheelwright, this last trade having been exercised in England before the 5th Eliz. But a wheelwright, though he has never served an apprenticeship to a coachmaker, might either himself make, or employ journeymen, to make coaches, the trade of a coachmaker not having been prohibited by the statute, as not being exercised in England at the time it was passed. All the great manufactures which, in modern times, have arisen throughout England—in Manchester, Birmingham, Sheffield, Wolverhampton—were on this account exempted from the restrictive operation of this law; and the perfection to which they have arrived seems a practical proof of its inutility for the encouragement of trade.

The effects of those restrictions imposed by the 5th Eliz. were at length felt to be so injurious, that, in the year 1813, petitions were presented to parliament from various manufacturing towns for a repeal of certain parts of this exceptionable statute; and the 54th Geo. III. was accordingly passed, by which all the penalties and prohibitions imposed by 5th Eliz. on those who should exercise any trade or mystery, unless qualified by six or seven years' apprenticeship, were repealed. That part of the statute was also repealed which enacted that no person should become an apprentice except in strict conformity to the provisions of the 5th Eliz., and which rendered all indentures contrary to this act null and void. In opposition to this, it was provided that all indentures or covenants which would otherwise be valid, should now be valid, any thing in the 5th Eliz. to the contrary notwithstanding.

APPRENTICESHIP, the servitude of an apprentice, or the duration of his indenture.

Seven years seem anciently to have been, all over Europe, the usual term established for the duration of apprenticeships in the greater part of incorporated trades. All such incorporations were anciently called *universities*, which indeed is the proper Latin name for any incorporation whatever. The university of smiths, the university of tailors, &c. are expressions which we commonly meet with in the old charters of ancient towns. When those particular incorporations which are now peculiarly called *universities* were first established, the term of years which it was necessary to study in order to obtain the degree of master of arts, appears evidently to have been copied from the term of apprenticeship in common trades, of which the incorporations were much more ancient. As to have wrought seven years under a master properly qualified was necessary in order to entitle any person to become a master, and to have himself apprentices in a common trade; so to have studied seven years under a master properly qualified was necessary to entitle him to become a master, teacher, or doctor (words anciently synonymous) in the liberal arts, and to have scholars or apprentices (words likewise originally synonymous) to study under him.

Apprenticeships were altogether unknown to the ancients. The reciprocal duties of master and apprentice make a considerable article in every modern code. The Roman law is perfectly silent with regard to them. There is no Greek or Latin word which expresses the idea we now annex to the word apprentice—a servant bound to work at a particular trade for the benefit of a master during a term of years, upon condition that the master shall teach him that trade.

Dr Smith considers the institution of apprenticeships as a device, by which trading corporations endeavour to confine to as few hands as possible the mystery of their craft, and by which, keeping the market always understocked with their particular sort of labour, they expect to regulate according to their discretion the price of such manufactures as they bring to market. He accordingly condemns all those laws which limit the number of apprentices to be taken by each master in particular trades, or which prescribe to apprentices a certain term of service before they are permitted to work as journeymen. The tendency of such laws, he observes, is to restrain the competition to a much smaller number than might otherwise be disposed to enter into the trade; the limitations of the number of apprentices restraining it *directly*, and a long apprenticeship restraining it *indirectly*, but as effectually, by increasing the expense of education. Long apprenticeships, or indeed any apprenticeship, for however short a term, Dr Smith considers quite unnecessary, as the nicest mechanical arts, such as the making of clocks and watches, contain, according to his theory, no such mystery as to require a long course of instruction. A few weeks, he calculates, or even a few days, would be sufficient to enable a mechanic to set to work in any of those trades; and if he were paid the full price for his work, he paying of course for such materials as he might spoil through awkwardness and inexperience, he imagines that he would learn his business more effectually, and be more apt to acquire habits of attention and industry, than when he works under a master who has a right to share in the produce of his labour.

It may be generally remarked, however, that, in his reasonings on these subjects, Dr Smith seems uniformly

disposed to overrate the practical effect of those expedients by which corporations have been always endeavouring to secure special advantages for particular trades; and that his theory respecting apprenticeships is only a part of that more general theory, by which he endeavours to show that the policy of Europe has always been to encourage the industry of the towns at the expense of that of the country; and that the effect of this policy has been to enable the merchants and manufacturers of the town, in bartering their produce for that of the country, to levy, for several centuries, an unjust and oppressive tax on the agricultural classes of the community. We know, however, that, according to the nature of human society, as it is so admirably explained in Dr Smith's work, monopoly can never succeed on so great a scale; and, on the same principle, we may rationally question, if the contract between the apprentice and his master were merely the device of corporations, whether it ever could have come into such universal use throughout Europe. The engagement by which the apprentice is bound to his master is his own voluntary act. He agrees to bind himself to work to his master at an inferior rate, on condition of receiving from his master the necessary instruction in his business. This instruction, Dr Smith asserts, may be given him in the course of a few days or weeks. It is well known, however, to every practical tradesman, or to any one acquainted with the nature of mechanical employments, that the instruction of three days or weeks would scarcely teach an apprentice the name of his tools, and that almost all the mechanical trades require throughout their various operations such nicety and exactness, that the necessary habits are not formed by the training of years, in place of weeks or days. It is for the troublesome superintendence of the apprentice during this period that the master exacts compensation, without which he would employ none but finished workmen. But he puts up with the awkwardness of his apprentice because he expects to be benefited by his labour after he shall be better instructed in his business; on the same principle that the farmer lays out his capital on the improvement of his land, in expectation of a future increase of produce. The contract of apprenticeship is thus a voluntary agreement between two parties for their mutual benefit, the result neither of law nor of the usages of petty corporations, but of circumstances. The law, indeed, takes cognizance of the contract, and enforces its fulfilment; and it may also have encumbered it with absurd regulations: but the contract itself stands independent both of law and usage, having its origin in the plainest principles of reciprocal expediency. There seems no reason, therefore, to class it with those artificial expedients which originate in the exclusive spirit of trading corporations.

Dr Smith appears also to have greatly overrated the effects of those laws, the object of which is to limit the number of apprentices who shall be reared to particular trades. No law of any corporation will ever be found in practice to impose any limitation on the number of apprentices who may be trained to a business. It will depend on the state of the business, whether it is advancing, stationary, or declining, what number of apprentices will be bred to it; and if, while a flourishing trade called for a continual supply of new hands, any corporation were to enact a law limiting the masters to such a number of apprentices as would barely keep up their present stock, a scarcity of hands would soon be felt, wages would rise, and the masters would soon be induced, by regard to their own interest, to rescind the law which imposed so great an inconvenience on themselves. But if the law is thus modified and accommodated to the state of the trade, it is a mere form. It imposes in reality no restraint, since it is always in the power of the masters to alter it whenever they feel that it interferes with their arrangements.

But though the law were even rigidly persisted in, it is evident that it would not permanently diminish the number of apprentices who would be bred to a business, since the consequence would be, that the workmen would turn masters, and each taking the full allowance of apprentices which the law permits, would soon train up an ample supply of hands. All those petty contrivances of corporations, therefore, though they may originate in the lowest mercantile jealousy, and though they may be exceedingly absurd, cannot materially disturb the general progress of things; and, though they may harass individuals, their effect on the industry of a great country hardly deserves notice; their bad effects being corrected by those general causes on which society depends for completing its arrangements, in spite of the obstacles arising from the mistaken policy of legislators. See Smith's *Wealth of Nations*, with Notes, and an additional volume of Dissertations, by David Buchanan.

APPROACHING, in fowling, a term used to express such devices as are contrived for the getting within shot of shy birds. It is principally used in marshy low places. The best method of approaching is by means of three hoops tied together at proper distances, according to the height of the man that is to use it, and having boughs of trees tied all round it, with cords to hang it over his shoulders. A man getting into this conceals himself, and approaches by degrees towards his game in the form of a moving bush. Geese, ducks, and teal, quit the waters in the evening, and pass the night in the fields; but at the approach of morning they return to the water, and even when on the water they will retire to great distances on the approach even of a horse or cow, so that the business of the stalking-horse is of little use; but this device of approaching by the moving bush is more successful.

APPROBATION, a state or disposition of the mind, wherein we put a value upon, or become pleased with, some person or thing.

APPROPRIATION, in the *Canon Law*, a severing of a benefice ecclesiastical to the proper and perpetual use of some religious house.

APPROVER, in *Law*, one who, professing felony in himself, appealeth or impeacheth another or more of his accomplices. He is so called from the French *approuver*, *comprobare*, because he must prove what he hath alleged in his appeal. This proof was anciently either by battle or by the country, at the choice of the appellee, and the form of this accusation may be found in Crompt. Just. 250.

APPROXIMATION, in *Arithmetic* and *Algebra*, the coming nearer and nearer to a root, or other quantity sought, without expecting ever to find it exactly.

APPULSE, in *Astronomy*, the approach of any planet to a conjunction with the sun or a star. It is a step towards a transit, occultation, conjunction, eclipse, &c.

APRIES, son of Psammis, king of Egypt, the same with Pharaoh Hophrah in Jeremiah and Ezekiel. He ruined Sidon, and some say he put Jeremiah to death. He thought neither God nor man could dethrone him, which yet was easily done by Amasis, and he himself was strangled by the Egyptians.

APRIL, the fourth month of the year, according to the common computation; but the second according to that of the astronomers. It contains 30 days. The word is derived from *Aprilis*, of *aperio*, I open, because the earth in this month begins to open her bosom for the production of vegetables.

APRON, in *Naval Architecture*, is a piece of curved timber fixed behind the lower part of the stern, immediately above the foremost end of the keel.

APRON is also a name given to a platform or flooring of plank, raised at the entrance of a dock, against which the dock-gates are shut.

APRON, in *Gunnery*, a piece of lead which caps or covers the vent or touch-hole of a great gun.

APSIS, in ecclesiastical writers, denotes an inner part in the ancient churches, wherein the clergy sat, and where the altar was placed. It is supposed to have been thus called because covered with an arch or vault of its own, by the Greeks called αψις, by the Latins *absis*. Apsis, in this sense, amounts to the same with what is otherwise called *choir*, *concha*, *camera*, and *presbyterium*; and stands opposed to the *nave* or body of the church.

APSIS is more particularly used for the bishop's seat in ancient churches. This was peculiarly called *apsis gradata*, because raised on steps above the ordinary stalls. It was also denominated *exedra*, and in latter times *tribune*.

APSIS is also used for a reliquary or case, wherein the relics of saints were anciently kept. It took the name *apsis* from its being round or arched at the top, or perhaps from the place where it was kept. The *apsis* was commonly placed on the altar; it was usually of wood, sometimes also of gold and silver, with sculptures, &c.

APSIS, in *Astronomy*, a term used indifferently for either of the two points of a planet's orbit, where it is at the greatest or least distance from the sun or earth; and hence the line connecting those points is called the line of the *apsides*. The word is Greek, and derived from απτω, *I connect*. The apsis, at the greatest distance from the sun, is called the *aphelion*, and at the greatest distance from the earth the *apogee*; while that at the least distance from the sun is termed the *perihelion*, and at the least distance from the earth the *perigee*.

APT, an arrondissement in the department of Vaucluse in France, extending over 500 square miles, or 380,000 acres. It is divided into four cantons, and those into fifty communes, containing 52,553 inhabitants.

APT, a city, chief of the arrondissement of the same name in France, situated on the river Calavon. It has a cathedral, and the inhabitants amount to 5374, who find employment in making cotton and silk goods, in distilleries, china manufactories, and especially in extracting essences from lavender, thyme, and other plants. It is in long. 5. 17. 47. E. and lat. 43. 52. 29. N.

APTHANE, a title anciently given to the higher degrees of nobility in Scotland. See THANE.

APTOTE, among grammarians, an indeclinable noun, or one which has no variation of cases.

APULEIUS, LUCIUS, a Platonic philosopher, well known by his performance entitled the *Golden Ass*. He lived in the second century, under the Antonines, and was born at Madaura, a Roman colony in Africa. He studied first at Carthage, then at Athens, and afterwards at Rome, where he learned the Latin tongue without the help of a master. He was a man of a curious and inquisitive disposition, especially in religious matters. This prompted him to take several journeys, and to enter into several societies of religion. He spent his whole fortune almost in travelling; so that at his return to Rome, when he was about to dedicate himself to the service of Osiris, he had not money enough to defray the expense attending the ceremonies of the reception, and was obliged to pawn his clothes to raise the necessary sum. He supported himself afterwards by pleading causes; and as he was a great master of eloquence, and of a subtile genius, many considerable causes were trusted to him. But he benefited himself more by marrying a rich widow named *Pudentilla*. This marriage, however, drew upon him a troublesome law-suit. His wife's relations, pretending he made use of sorcery to gain her heart and money, accused him of being a magician, before Claudius Maximus, proconsul of Africa. Apuleius found no great difficulty in making a successful defence. His *Apology*, which is still extant, contains some very curious details. Apuleius was indefatigable in his studies, and composed many works, some in verse, and others in prose; but most of them have been lost. He took great pleasure in declaiming, and was heard generally with applause. The citizens of Carthage erected a statue to him, and several other cities did him the same honour. There have been upwards of forty editions of his works; of which the first and rarest was published at Rome in 1469, the last and best at Leyden in 1786–1823, in 3 vols. 4to. This edition was begun by Oudendorp, and published after his death by Ruhnkenius and Bosscha. His principal pieces, besides the celebrated fiction of the *Golden Ass*, are his *Apology*, entitled *Oratio de Magia*; fragments of speeches, entitled *Florida*; three books of philosophy, entitled *De Habitudine Doctrinarum et Nativitate Platonis*; and a curious treatise, *De Deo Socratis*.

APYCNI SUONI, in *Music*, sounds distant one or more octaves, and yet concord.

APYCNOS, in *Music*, is said of the diatonic genus, on account of its having spacious intervals, in comparison of the chromatic and enharmonic.

APYREXY, among physicians, denotes the intermission of a fever.

APYROUS, a word applied to denote that property of some bodies, by which they resist the most violent fire without any sensible alteration. Apyrous bodies ought to be distinguished from those which are refractory. Refractory substances are those which cannot by violent heat be fused, whatever other alteration they may sustain. But a body, properly speaking, apyrous, can neither be fused by heat, nor undergo any other change. Diamonds were long thought to be possessed of this property; but experiments have shown that diamonds may be entirely dissipated or evaporated by heat, and are therefore not entitled to be ranked among apyrous substances. Perhaps there is no body in nature essentially and rigorously apyrous. But it is sufficient that there be bodies apyrous relatively to the degree of fire which art can produce, to entitle them to that name.

AQUA, a term frequently met with in the writings of physicians, chemists, &c. for certain medicines or menstruums, in a liquid form, distinguished from each other by peculiar epithets.

AQUA Exstincta, or *Extinguished Water*, is aqua fortis into which some river water has been poured, in order to qualify it, and render it less corrosive.

AQUA Fortis, a name given by artists to nitric acid of a certain strength, from its dissolving power.

AQUA Marina, a name by which the jewellers call the beryl, on account of its sea-green colour.

AQUA Regia, a compound of nitric and muriatic acid, in different proportions, according to the purpose for which it is intended. It is usually made by dissolving in nitric acid either sal ammoniac or common salt, both of which are combinations of muriatic acid with alkali.

AQUA Secunda, aqua fortis diluted with much pure water. It is employed in several arts to clear the surface of metals and certain stones.

AQUA Tofana, called also *Aqua della Toffanina*, or *Aqua della Tofa*, from its supposed inventress,—*Aqua del petesino*,[1]—*Aquetta di Napoli*, or simply *Aquetta*,—a poi-

[1] Lanzoni *Opera*, vol. i. p. 69. Lausannæ, 1738, 3 vols. 4to.

sonous liquor which was used to a very great extent at Naples and Rome during the latter half of the 17th century. Gmelin[1] says that more people were destroyed by it than by the plague, which had prevailed a short time before it came into use; and Garelli, chief physician to the emperor, wrote to Hoffmann that Tofania confessed she had used it to poison more than 600 persons. This he learnt from the emperor himself, to whom the whole criminal process instituted against her was transmitted.[2]

It is to be regretted that Garelli, who had such an authentic source of information, has not given us some details of the infamous Tofana or Tofania, as the little that we know of her rests upon the authority of travellers, and is evidently exaggerated, and sometimes irreconcilable with established facts. She was a Sicilian by birth, and resided first at Palermo, and then at Naples. When she began to exercise her horrible profession, is nowhere stated; but it will presently appear that it must have been at a very early age, and before 1659. She was extremely liberal of her preparation, chiefly, it is said, to ladies tired of their husbands; and the better to conceal the nature of her gift, it was put up in small flat phials, inscribed *Manna of St Nicholas of Bari*, ornamented on one side with an image of the saint, that it might pass for a liquid said to drop from his tomb at Bari, which was in great request on account of the medicinal virtues ascribed to it. Nor is it ascertained how long she carried on her murderous practices with impunity and undiscovered. Labat[3] says, that when he was at Civita Vecchia in 1709, the viceroy of Naples, then Count Daun, made the discovery. It was long before she was secured, as she was extremely cautious, and often changed her abode or retired into convents. At last she was betrayed, and, although in a convent, was seized and carried to the Castel del Uovo, where she was examined. Cardinal Pignatelli, then archbishop of Naples, indignant at the violation of a religious sanctuary, threatened to excommunicate the whole city if she was not delivered up to him; and the people were ready to rise. But the sagacious viceroy caused a report to be spread that she and her accomplices had determined upon the same day to poison all the springs in the city, the fruits brought to market, and the public granaries. The manœuvre succeeded. The credulous people were now clamorous for her punishment, and saw with satisfaction the persons whom she accused of having purchased her *Aquetta* taken from the churches and monasteries. Some of inferior birth were executed publicly, those of higher rank secretly in prison; and the whole city resounded with the praises of the viceroy, whose energy had saved it from general destruction. A kind of compromise was entered into with the cardinal; in consequence of which, after being strangled, her body was thrown at night into the court of the convent, by way of testifying some respect for the rights of the church. But the reverend traveller must have either been misinformed as to the actual execution of this Medea, or she must have been resuscitated; for Garelli expressly says that she was alive in prison at Naples when he wrote to Hoffmann, not long before 1718; and Keysler, who visited Naples in 1730,[4] likewise asserts that she was then living in prison, and that few strangers left the city without going to see her. He describes her as a little and very old woman.

The Roman ladies very quickly availed themselves of Tofania's discovery; for it was remarked in 1659, that many husbands died when they became disagreeable to their wives; and several of the clergy also gave information that, for some time past, various persons had confessed themselves guilty of poisoning. This led to the detection of a society of young married women (who had for their president an old woman of the name of Hieronyma Spara, a pretended fortune-teller), as the perpetrators of these murders. On being put to the torture they all confessed except Spara, who seemed to rely upon the protection of powerful individuals whom she had formerly served. But she was left to her fate, and was hanged along with her assistant, one Gratiosa. Others were afterwards hanged, or whipt and banished. Spara, who was a Sicilian, had acquired her knowledge from Tofania at Palermo.[5]

Pope Alexander VII., immediately on the discovery and punishment of those who dealt in poison in his capital, published an edict forbidding the distillation of aqua fortis, or the purchase of any of its ingredients, without the permission of the government; which Gmelin considers as an artifice to mislead the people as to the real composition of the poison, or as originating in the absurd nomenclature of the chemists of former times, who called arsenic concrete aqua fortis. But the prudence of the Pope was rendered fruitless; for we are informed by Gayot di Pitaval (*Causes Celèbres*, vol. i. p. 317, Amsterd. 1764), on what authority he does not state, that Tofania's fatal secret was disclosed by the indiscretion of the judges at Naples, to whom she had made confession of her crime. The whole city soon knew that she employed in its composition a very common herb, and that its preparation was otherwise easy; and in this way the art of poisoning became very common in Naples, where, Keysler says, it was still secretly practised when he visited Italy; and Archenholz,[6] who was there in 1780, states, that Aqua Tofana was then in use, although its composition was only known to a few; but Joseph Frank, who was long professor in Pavia, and has written a work on toxicology (*Handbuch der Toxicologie*, p. 168, Wien, 1803), regards this as an unfounded calumny, and asserts that it no longer exists or is heard of.

Aqua Tofana is described as being as limpid as rock water, and without taste, and hence it could be administered without exciting suspicion. The Abbé Gagliani adds,[7] that there was not a lady in Naples who had not some of it lying openly on her toilet among her perfumes, in a phial known only to herself.

It was generally believed that the effect of this poison was certain death, and that it could be so tempered or managed as to prove fatal in any determinate time, from a few days to a year or upwards. Four or six drops were reckoned a sufficient dose, and they were said to produce no violent symptoms, no vomiting, or but very seldom;

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[1] *Allgemeine Geschichte der mineralischen Gifte*, 1st edit. 8vo, Nurnberg, 1777, p. 132; 2d edit. 8vo, Erfurt, 1811, p. 243.

[2] F. Hoffmanni *Med. Rat. Syst.* P. ii. cap. ii. sect. 19. *Opera Omnia*, 6 vols. folio, Genevæ, 1748, vol. i. p. 198.

[3] *Voyage en Espagne et en Italie*, 8 tomes 8vo, Paris, 1730, vol. iv. p. 33.

[4] *Travels through Germany, &c.* 4 vols. 4to, 2d edit. London, 1756, vol. ii. p. 368.

[5] J. F. Le Bret, *Magazin zum Gebrauche der Staaten-kirchengeschichte*, iv. Frank. 1774, p. 131–141, as quoted in the curious chapter on *Secret Poisons*, in Beckmann's *History of Inventions and Discoveries*—a work which has been of great assistance to us in pointing out authorities.

[6] *England und Italien*, 5ter Theil, 8vo, Carlsruhe, 1787, p. 184.

[7] Weckherlin's *Chronologen*, 12ter Band, p. 146—*L'Espion Dévalisé. Feliciter Audax*, London, 1782, p. 61; also Behrends, in Pyl's *Magazin für gerichtliche Arzneikunde und medicinische Polizey*, book i. st. 3, 1784, p. 428–477.—Beckmann.

no pains, convulsions, inflammation, or fever;[1] but only a feeling of indisposition, without any very definite symptoms, except sometimes inextinguishable thirst: the victim, however, sunk into a languid state, and his weakness increased daily. Disgust at all kinds of food, and weariness of life, succeeded: the nobler organs were then attacked, the lungs were wasted by suppuration, and death closed the miserable scene. This termination was the more certain, that the true cause of these symptoms was not at first suspected, and the remedies commonly prescribed rather aggravated the evil. Indeed, even when known, no treatment was of any avail, although a Dr Branchaletti, according to Keysler, wrote a book on its remedies, until it was discovered by accident that lemon-juice, when very early administered in large doses, sometimes proved effectual (Bertholinus), after which Keysler tells us that the poison fell into some disrepute.

Various accounts of the composition of this detestable liquor have been given. Abbé Gagliani, and more lately Archenholz, state it to be a preparation of cantharides and opium; but this is perfectly inconsistent both with its appearance and effects. By no preparation can the smell and taste of opium, if the quantity be sufficient to produce any effect, be concealed; and the acrimony of cantharides is equally connected with its activity. The one of these drugs is highly stimulant, the other a sedative, and neither of them capable of remaining latent in the system, or injuring the constitution. Erndtel,[2] but without any probability, has conjectured that the chief ingredient was lead: Halle (*Die deutchen Giftpflanzen*, Berlin, 1703) believes that it was prepared from the frothy saliva gathered round the mouth of a person tortured to death. Garelli, on the contrary, positively asserts it to have been nothing but a solution of crystallized arsenic in a large quantity of water, with the addition, for some unknown reason, of a very innocent herb, the *Antirrhinum cymbalaria*. The same account is given by Bertholinus, Lobel (*Der freymüthige Heilkunstler*, Berlin, 1786), Plenk (*Toxicologia*, p. 335), Haller,[3] Molitor (*Commerce Lit. Noric.* 1737, p. 132), and Möhsen,[4] and is received by the most judicious systematic writers, as Gmelin and Hahnemann. (*Ueber die Arsenikvergiftung*, p. 35. Leipzig, 1786, 8vo.) Wildberg,[5] however, considers its composition to be unknown.

From Italy this poison seems to have found its way to Paris. In 1672 Godin de Sainte Croix, an adventurer, who lived in a scandalous intimacy with the Marchioness Brinvilliers, was suddenly killed by suffocation, as it is said, in consequence of the falling off of a mask of glass, which he wore to protect him from the fumes of certain chemical operations about which he was employed. As he had no known relations, his effects were examined by a public officer, and among them was found a casket, containing many packets of poisonous articles, sealed up in a mysterious manner, together with a kind of last will, directing the whole to be delivered to the marchioness, and, in case of her having predeceased him, to be burnt unopened. This led to the discovery of his having been instructed in the art of preparing poison by an Italian, called Exili, with whom he had become acquainted when confined in the Bastile; and of his having furnished the marchioness with the means of poisoning her father and her two brothers, besides others on whom she tried the effect of her preparations. One of these afterwards was called from her by the name *Eau de Brinvilliers*. She is also said to have employed a powder called *Poudre de Succession*.[6] La Chaussée, who had been valet to Sainte Croix, was convicted of being accessory to these murders, and was broken alive on the wheel. The marchioness herself, who had escaped to Liege, was also seized; and her execution, which took place on the 17th of July 1676, is described with revolting levity by Madame de Sevigné in a letter to her daughter of that date.

The practice of poisoning, however, did not seem to terminate with the death of this infamous woman; and a particular court called *Chambre des Poisons*, or *Chambre Ardente*, was established in 1679, to endeavour to put an end to it. In consequence of the investigations which took place in it, many persons, some of the highest rank, especially the Duc de Luxembourg, were implicated. More than 40 persons were at one time confined in the Bastile; but it was ascertained that almost all of them had been guilty of no crime, but were merely the dupes of a few impostors, who pretended to raise spirits, foretell future events, and to possess many secrets of a similar nature. Two women, La Vigoreux and La Voisin, with the brother of the former, and a priest called Le Sage,[7] pretended fortune-tellers, were convicted of being dealers in poison, and burnt alive on the 22d of February 1680; some others were hanged, and others acquitted. This closed the proceedings of this inquisitorial court, which has been accused of being a political engine, contrived to serve the purposes of Louvois and the Marchioness de Montespan. Voltaire, however, admits that the crime of poisoning infected Paris from 1670 to 1680.

Concerning the effects of the *Eau de Brinvilliers*, Pitaval tells us (p. 271) that the marchioness's father experienced violent effects from the poison,—extraordinary vomiting, insupportable pain at the stomach, and great heat in the bowels. He died soon after his return from his country-seat to Paris. The brothers and five other persons were all taken ill, and affected with vomiting, after partaking of a tart at dinner. On their return from the country to Paris, the brothers had the appearance of persons who had been long ill; and after suffering, the one for two, and the other for three months, from nausea and vomiting, they died extremely emaciated, and as it were dried up, without fever, though experiencing a burning sensation in the stomach. On opening the bodies, the stomach and duodenum were black and tender, and the liver gangrenous and burnt. Madame Sevigné relates that the marchioness often poisoned her husband, that she might marry Sainte Croix; but that the gallant, having no desire for a wife of her disposition, as often gave the poor husband an antidote. She is also said to have attempted to poison her sister, but did not succeed; and

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[1] Bertholinus alone enumerates very violent fever as its first effect. See J. J. Wepferi *Historia Cicutæ Aquaticæ*, p. 372. Lugd. Bat. 1733, 8vo.

[2] *Dissert. de Veneno salutem sistens*, Lipsiæ, 1701, § 21.

[3] *Vorlesungen über die gerichtliche Arzneikunde*, 2ter Band, p. 190.

[4] *Beschreibung einer Berlinischen Medallien-Sammlung*, 1. Th. p. 148.

[5] *Handbuch der gerichtlichen Arzeneywissenchaft*, p. 224. Berlin, 1812, 8vo.

[6] Heucher, *Mithridates, sistens præservationem Principis a veneno.* Vide ejus Opera, 4to, Lipsiæ, 1745, vol. I. p. 421; also, J. G. Arnold pr. C. G. Stentzell *De Venenis terminatis et extemporaneis, quæ Galli* les Poudres de Succession *vocant.* This powder was probably an arsenical composition; but it was supposed by Erndtel and Haller to be acetate of lead, and by Brendel (*Institutiones Medicina Legalis*, Halæ, 1768) to consist of lead and bismuth.

[7] Voltaire, *Siècle de Louis XIV.* chap. xxvi.

that she was in the habit of trying the effects of her poisons on the poor, and even on the patients in the Hotel Dieu, under pretence of charitably supplying them with biscuits. But Voltaire positively denies this horrible imputation, and says that she never attempted the life of her husband, who overlooked a connection of which he was the cause.

The information concerning the nature of the *Eau de Brinvilliers*, derived from the examination of Sainte Croix's famous casket, is not satisfactory. It contained poisons enough to have killed a whole community; besides opium, lunar caustic, antimony, and vitriol, more than 75 lbs. of corrosive sublimate, and two bottles of a liquid like water, with a sediment in one. The clear liquid was probably his real poison; as none of the other substances could have been given so as to produce death, without instantly being detected by their abominable taste; but what this liquid was, we can now only conjecture; for its examination, as reported by Pitaval, shows that the physicians at that time had not the slightest notion of the mode of detecting arsenic even in substance, much less in solution; and accordingly, although both the liquor and powder killed the animals to which they were given, it is candidly admitted that the poison of Sainte Croix surpassed the art and capacity of the physicians, and that it baffled all their experiments to discover its composition. We have, however, no doubt that arsenic was the only active ingredient of all these pretended secret poisons, as it is the only substance capable of explaining all the credible circumstances related of them. From the mode of administering them in small but repeated and perhaps increased doses, there was some foundation for the belief that they could be given so as to kill in any determinate time, while their failing in any instance to produce death was easily accounted for by supposing antidotes to have been administered. But although the progress of knowledge has proved that there is no such thing as such antidotes, it has on the other hand, by rendering the detection of poison easy and certain, put a stop for ever to the trade of *poisoner*, and, what is perhaps of equal importance, to the general alarm and cruel punishment of individuals, which have often resulted from natural deaths being ascribed to poison. It is not because we know less, but because we know a great deal more than our forefathers, that the art of secret poisoning seems to be lost. (x.)

AQUAMBOE, a large kingdom in the interior of the Gold Coast of Africa, extending 20 miles along the banks of the Rio Volta, which separates it from Aquapim, and reaching 100 miles inland. About a century ago it was considered the most powerful kingdom on all this coast, and the king held all the neighbouring potentates as his subjects or tributaries. His despotism gave rise to a proverbial saying, that "there are only two ranks of men in Aquamboe, the royal family and slaves." The natives are haughty, turbulent, and warlike; and their territory, though fertile, is indifferently cultivated. Like all the countries in the interior from the Gold Coast, it is now entirely subject to the preponderant power of the king of Ashantee.

AQUAPENDENTE. See Fabricius.

AQUAPIM, a kingdom of considerable extent in the interior of the Gold Coast of Africa, immediately behind Acra, and having on the other side Aquamboe. This country is said to vie in beauty and fertility with any in the world. It is finely diversified with wooded hills and highly cultivated valleys, the former having usually towns and villages situated on their summits. The people are obedient to their chiefs, mild and gentle; they are chiefly employed in agriculture, which they practise with considerable diligence.

AQUARIANS, Christians in the primitive church who consecrated water in the eucharist instead of wine. This they did under pretence of abstinence and temperance, or because they thought it universally unlawful to eat flesh or drink wine. Epiphanius calls them *Encratites*, from their abstinence; St Austin, *Aquarians*, from their use of water; and Theodoret, who says they sprang from Tatian, *Hydroporastatæ*, because they offered water instead of wine. Besides these, there was another sort of Aquarians, who did not reject the use of wine as unlawful; for they administered the eucharist in wine at evening service; but in their morning assemblies they commonly used water, lest the smell of wine should discover them to the heathens.

AQUARIUS, the Water-bearer, in *Astronomy*, the 11th sign of the zodiac. It is marked thus, ♒. The poets feign that Aquarius was Ganymede, whom Jupiter ravished under the shape of an eagle, and carried away into heaven to serve as a cup-bearer in the room of Hebe and Vulcan; whence the name. Others hold that the sign was thus called because, when it appears in the horizon, the weather usually proves rainy.

AQUATINTA Engraving, so called from its near resemblance to water-colour drawings, is of modern invention, and was much practised about 12 or 15 years ago, since which period it has not been so much in fashion.

It is performed in a variety of ways; but the most approved is by covering or immersing the copper-plate in a solution of resinous matter, rendered so in rectified spirits of wine, and by working or drawing the object which is wished to be represented, upon the plate, with a prepared pigment, commonly called the bursting ground. These solutions and grounds are made of a variety of substances, described in recipes at the end of this article.

The work is generally commenced by etching, or tracing the outline upon the plate with an etching needle or other sharp instrument, which being done, and the etching ground removed, the plate must be made particularly clean and free from grease, with whitening and water. The plate is then to be placed in a flat tin or earthen vessel, in an inclined position, and the resinous solution or ground (No. 1, &c.) poured quickly upon it from the top to the bottom, so that the superfluous ground may run off, and be preserved for after-use in a vessel so placed as to receive it. Should the subject to be engraved be a landscape, it will be advisable to allow the ground upon the plate to dry in the inclined position, because the granulation of the shade or tint has a tendency to be closer and finer in proportion as it is nearer the top of the plate; and in this way the sky is represented by the finest grain at the top, and the foreground by the coarsest at the bottom of the plate. Should the subject require an equality of tint or grain, it will be procured by reversing the inclined position of the plate backwards and forwards as quickly as possible after the ground has been poured on it. The spirit of wine will very speedily evaporate, leaving the plate dry, with the ground upon it ready for work; but in order to render it more secure, it may be held over a clear fire, with the back of the plate next the coals until the resin of the ground is a little heated, and so fixed to the plate more completely. Care must, however, be taken, in this operation, not to melt the resinous granulations so much as to cause them to unite into solid masses.

The design is now to be drawn upon the plate with the bursting ground (No. 10, &c.), exactly in the same manner as any water-colour drawing is set about: every part where a tint is required is to be covered over with the bursting ground, and the lights alone left untouched with it. When this composition is quite dry, take a broad camel-

Aquatinta engraving.

hair pencil, such as is used for painting skies, and go over the whole surface of the plate with the varnish (No. 13). The plate is now to be surrounded with a border of wax (14), so as to retain the aqua fortis. When the varnish is dry, as much clean water must be poured upon the copper as can be contained within the border wax, and in about 15 minutes the bursting ground will burst open the varnish, and leave the aquatinta ground ready for being bit in with the diluted acid. The bursting away of the bursting ground may be aided with the help of a clean camel-hair pencil or goose-quill feather; but if the composition be properly made this will not be necessary. The plate may now be said to be ready for the first tint being bit in with the aqua fortis, which must be allowed to remain upon it until the shade is seen to be of a proper colour, when the acid must be poured off, and the plate cleaned with water, to prepare it for the second tint; which is to be accomplished in the same manner as described for the first; and thus the greatest softness of shade, and the utmost sharpness of touch in the foreground or sky, may be attained. A pair of bellows may be used to dry the plate more quickly between the bitings with the aqua fortis, and so prevent the copper from becoming corroded by the water. From the description above given, it will be obvious that in some cases the bursting ground will not be required, and that the lights alone will need to be stopped out with the varnish;—such as in fleecy white clouds, the high lights upon metallic substances, &c.; all which practice will soon suggest to the artist.

Before we proceed to describe some other modes of performing this operation, we may remark, that when very fine grounds are required, it is customary only to bite in the lightest shades with the first granulation, and then to clean the plate and lay on a second, or even a third and fourth ground, at various stages of the work. But it must be held in mind, that in proportion as the grounds are multiplied, the granulations are subdivided, and their rich grain lost; while at the same time the work is rendered less serviceable, by its casting off a smaller number of impressions.

Should the bursting ground not flow on the plate freely out of the camel-hair pencil, in consequence of the plate being greasy, it may be washed with very weak aqua fortis before commencing. If the weather should be very cold, it is difficult to obtain a good ground; on which account it will be advisable to heat the apartment with a stove to a moderate summer heat.

Dust Grounds are prepared by covering the plate with powders of various mixtures, and fixing them by holding it over a clear fire; and the operation of biting in the subject with the aqua fortis, and the painting of the objects upon the plate, may be performed in the manner above described, and either with or without the bursting grounds. The powders may be applied to the surface of the copper in a variety of ways. As good a mode as any is to cover over the top of a small box with one or two layers of muslin, and dust the powder through these layers of muslin equally upon it. For this purpose the plate will require to be a little greasy, that the powder may adhere the more readily; and when the whole surface is covered, give the plate a sharp stroke upon the back, that the superfluous particles may be disengaged.

Madame Prestel's ground, celebrated for its fineness, is produced in the following manner: The plate is placed with its face upwards in a box, about six inches deep, covered with a lid: at one end introduce through a circular hole the small end of a hair-dresser's powder machine, filled with finely pulverized resin, and work it till the plate is completely covered with the powder, which fix over a clear fire, as already described.

Spirit Grounds.

No. 1. *Resin Ground.*—One quart of double rectified spirits of wine, and ten ounces of common resin: when dissolved, a variety of granulations will be obtained by adding spirits of wine to this solution.

No. 2. *Burgundy pitch ground.*—One quart of spirits of wine and ten ounces of Burgundy pitch: the coarseness or fineness of this, as well as the former ground, is influenced by the greater or less quantity of spirits in which the pitch is dissolved.

No. 3. *Mastic ground.*—Four ounces of gum mastic to one pint of spirits of wine: this, if made a month before being used, will be found to be a good ground.

No. 4. *Animi ground.*—Eight ounces of gum animi to one quart of spirits of wine.

No. 5. *Frankincense ground.*—Twelve ounces of gum frankincense to one quart of spirits of wine.

No. 6. *Turpentine varnish ground.*—One fourth of a pint of turpentine varnish to three fourths spirits of wine makes a curious granulated ground.

All these compositions may be mixed one with another, or even two or three may be combined; and the results, interesting in consequence of the variety of granulations which will be produced, and, as mentioned before, the coarseness and fineness, will vary in proportion to the quantity of spirits which are used.

Dust Grounds.

No. 7. Equal parts of asphaltum and fine transparent resin, finely powdered separately, and afterwards completely mixed together.

No. 8. Gum sandarach finely powdered.

No. 9. Transparent resin finely powdered. These powders may be so pulverized as to produce fineness or coarseness of granulation.

Bursting Grounds.

No. 10. Half a pound of treacle, half an ounce of isinglass, and eight ounces of gum arabic, in no more water than will just dissolve them. This should be set by for a week, shaking it up twice a day: when used, a little must be poured into a cup, and as much lamp black, burnt cork, or *terra de sienna*, ground as finely as possible, added to it as will give it both body and colour. Should it be too stiff to work, add a little water.

No. 11. Half a pound of treacle, four ounces of white sugarcandy, and one ounce of gum arabic, dissolved in a little water, at least a week before using.

No. 12. Half a pound of West Indian white sugar, an ounce and a half of isinglass, and one ounce of gum dragon, dissolved in as much malt liquor of any kind as will make them liquid; set them on the fire until all are well melted, and, when cool, the composition may be used immediately. These two last recipes may be coloured with the same substances as No. 10.

No. 13. The varnish used for covering over these bursting grounds is common turpentine varnish, thinned down with turpentine to the proper consistency required.

No. 14. Border-wax is composed of equal parts of shoemaker's resin and bees-wax.

The preceding is the method for prints of one single tint. But if different colours are to be expressed, there will be required as many different plates, each plate having only the part etched upon it which is designed to be charged with its proper colour; unless (as may happen in particular subjects) some of the colours are so distant from each other as to allow the printer room to fill them in with his rubber without blending them; in which case

two or more different colours may be printed from the same plate at once. Where different plates are necessary, a separate one, having a pin in each corner, must be provided as a sole or button to the aquatinta plates; and these again must be exactly fitted, having each a small hole in their corners for passing over the pins of the sole; the said pins serving the double purpose of retaining the plates successively in their due position, and of directing the printer in placing the paper exactly on each plate so as not to shift; by which means each tint or colour will be exactly received on its proper place. A landscape or similar subject, however, may be printed off at once in the different proper colours, by painting these upon the plate. In this case the colours must be pretty thick in their consistence; and the plate must be carefully wiped in the usual way after the laying on of each tint, as well as receive a general wipe upon its being charged with all the tints. For more particular information upon this art, see the third edition of Green's *Complete Aquatinta*. Lond. 1810.

AQUEDUCT, a conduit or channel for the conveyance of water. It is derived from *aqua*, water, and *ductus*, a conduit. It is applied more particularly to those structures of masonry which have been erected for the conveyance of water across valleys, to which, however, we would rather give the name of aqueduct bridges, extending the term aqueduct to the whole conduit or channel by which the water is conveyed from one place to another. The conveyance of water for the supply of large cities has in all ages formed a very important object of public economy; and aqueducts of various kinds have been in use for this purpose from the earliest times, the remains of which have been examined by travellers in different parts of the East. Pococke describes a work of this kind erected by Solomon, for conveying water from the pools and fountains near Bethlehem to Jerusalem. "The aqueduct," he says, "is built on a foundation of stone; the water runs in round earthen pipes about 10 inches diameter, which are cased with two stones, hewn out so as to fit them, and they are covered over with rough stones well cemented together; and the whole is so sunk into the ground on the side of the hills, that in many places nothing is to be seen of it." But it was in the luxurious capital of Rome that the system of aqueducts was brought to the greatest perfection, and carried to an extent which has never been equalled even in modern times, and has justly excited admiration both from the number and magnificence of the works themselves, and the prodigious quantities of water which by these means were continually poured into the city. These aqueducts extended, some of them 30, 40, and even 60 miles from the city, in one continued covered channel of stone, carried by arcades over the widest and deepest valleys, and by tunnels running in many parts for miles through mountains and through the solid rock. "If we consider attentively," says Pliny, "the quantities of water brought into the city for the use of the public, for baths, for fish-ponds, for private houses, for artificial lakes, for gardens in the neighbourhood of the city, and for villas; if we look also at the works which have been constructed for forming a regular channel for the waters—arches raised up, mountains pierced with tunnels, and valleys filled up to a level; it must be acknowledged that there is nothing in the whole world more wonderful."

For about 400 years after the building of the city the Romans were contented with the waters of the Tiber, or what was drawn from wells or from fountains in the city and its neighbourhood. But the great increase of the population rendering a more ample supply desirable, the censor Appius Claudius was the first to introduce an aqueduct to convey the waters of distant springs into the city. About thirty-nine years after this, M. Curius Dentatus brought in an additional supply from the neighbourhood of Tibur. These examples were afterwards followed by various other public men, as the wants of the city rendered new supplies necessary. Among these were Papirius, Crassus, Marcius, Agrippa, and Augustus; and most of the succeeding emperors, even Tiberius, Claudius, Caligula, Nero, and Caracalla, esteemed it an honour to connect their names with such great and useful works.

Frontinus, who was appointed curator of the aqueducts by the emperor Nerva, has left the most ample account of them. According to him, there were nine great aqueducts by which the city was supplied. Five more were added by Nerva, and the number was afterwards augmented by succeeding emperors to twenty. Of these, the most remarkable were the Aqua Appia; the Old and New Anio; the Aqua Martia, which also conveyed the Aqua Julia and the Aqua Tepula; the Aqua Virginia; and the Aqua Claudia. The *Aqua Appia* was so named from the censor Appius Claudius, by whom it was constructed in the 442d year of Rome. It commenced in a field near the Via Prænestina, between the 6th and 8th mile-stones, made a circuit of 780 paces to the left, and then proceeding by a deep subterranean channel of more than 11 miles, entered the city at the Appian Way by the Porta Capena, and delivered the main body of its waters into the Campus Martius. The *Old* and *New Anio* were so called from their bringing into Rome the waters of that river. The former began above the Tiber, at the 30th mile-stone, and consisted mostly of a winding channel, carried through an extent of about 43 miles. The latter, constructed under Nero, took a higher level, running 7543 paces above ground, and then through a subterranean passage of 54,267 paces in length. The *Aqua Martia*, which owed its formation to Quintus Martius, rose from a spring distant 33 miles from Rome, made a circuit of three miles, and afterwards forming a vault of 16 feet diameter, it ran 38 miles along a series of arcades at an elevation of 70 feet. It had openings perforated at certain distances for discharging the collected air, and at different places deep cisterns, in which the water settled and deposited its sediment. On this account it was remarkable for its clear green colour, and is celebrated by Pliny for its coolness and salubrity. The *Aqua Julia* and the *Aqua Tepula* were brought to Rome by the same aqueduct as the *Aqua Martia*, but on higher levels. The whole aqueduct above the arcades was divided into three stories or channels. In the uppermost flowed the Aqua Julia, in the second the Aqua Tepula, and in the lowest the Aqua Martia. From the ruins of this combined fabric, which still subsist, it appears to have been a very superb structure. The *Aqua Virginia* was constructed by Agrippa, who laboured to improve and beautify Rome, and who, according to Pliny, formed in one year 70 pools, 105 fountains, and 130 reservoirs. It commenced at a very copious spring, in the middle of a marsh, at the distance of eight miles from the city, and ran about 12 miles, passing through a tunnel of 800 paces in length. The *Aqua Claudia*, begun by Nero and completed by Claudius, took its rise 38 miles from Rome. It formed a subterranean stream $36\frac{1}{4}$ miles in length, ran $10\frac{3}{4}$ miles along the surface of the ground, was vaulted for the space of three miles, and supported on arcades through the extent of seven miles, being carried along as high a level as to supply all the hills of Rome. It was built of hewn stone, and still continues to furnish the modern city with water of the best quality, which has hence procured it the name of *Aqua Felice*.

In all these aqueducts the channel for the waters was carried with a regular declivity from the one end to the

other of the aqueduct, and such as was sufficient to carry the water easily along. In some cases the declivity, had the line been carried straight forward, would have been too great; it was therefore made to take a circuitous route, winding along the sides of the hills, and prolonging the length of the channel so as to reduce the degree of descent, and cause the water to run gently along. The whole of the channel was regularly built of stone or brick, and arched above to cover in the channel, excepting in those places where it was cut out of the solid rock. Along all the valleys and water-courses which lay in the way it was elevated by a series of arches, all raised to the level of the conduit, resting on massy pillars, and all built in the most solid and substantial manner, with brick, and often with hewn stone. The sketches of Roman aqueducts in Plate XLVIII., taken from Fabrettus, will give a better idea than any description, of the manner in which the work was executed. Sometimes there was only a single arch, as in the two middle figures; sometimes, again, where the conduit was to be elevated higher, as in the right-hand figure, a double row of arches was raised, one above the other, for greater strength and security. The figure on the left hand shows two conduits or aqueducts carried in different levels along the same building. The upper one is the New Anio, the lower is the Aqua Claudia. When we consider the labour and difficulties attending the construction of such arches and arched channels of masonry, the spirit and enterprise which could have undertaken such works as are above enumerated, undaunted by the expense, or any of the other obstacles which lay in the way, appear astonishing. In this country, where bridges, canals, and other water-works have been carried to a great extent and perfection, we consider an aqueduct of six or eight arches a work of no small extent and importance. What would we think, then, of the aqueduct of the New Anio, extending 6½ miles in one continued series of arches, many of them upwards of 100 feet high! If we allow a similar number of arches in the length, we shall have in all more than 600; and yet this is nothing compared with the aqueduct of the Aqua Martia, extending 38 miles, and containing in all nearly 7000 arches. Even an aqueduct bridge of five or six miles in length appears incredible; and yet how can we otherwise translate Frontinus, where he states the lengths of all the aqueducts, and how much was above or under ground, and how much was built in arches? Of the New Anio, for instance, he says its conduit was 63 miles 700 paces in length. Of this 49 miles 200 paces consisted of a subterranean stream, and 9 miles 400 paces were above ground, of which last the higher part consisted of "substructionibus aut opere arcuato," in several places of great length; and nearer the city, at the 7th mile-stone, consisted of "substructione" 609 paces, and "opere arcuato" 6 miles 491 paces; and he adds, "These arches are the highest of any, being raised in some parts 109 feet." The term *substructio* probably means a conduit built by opening up the surface of the ground and then covering over the building with earth, as we do in such works at this day. But the term *opere arcuato* can only refer to a continued series of arches, and certainly conveys a vast idea of the extent and magnitude of such works.

The total quantity of water delivered into Rome by these aqueducts was altogether astonishing, and quite beyond what we have any conception of now, for either comfort or luxury. Strabo said truly, that whole rivers flowed through the streets of Rome. According to Frontinus, the nine earlier aqueducts delivered daily 14·018 quinaria, which corresponds to nearly 28 millions of cubic feet; and when all the aqueducts were in operation, the quantity must have amounted to 50,000,000 cubic feet; which, reckoning the population of the city at that time at a million, would give 50 feet daily, or 7 hogsheads to each individual. This is more than ten times the supply of London, which is now reckoned to be quite profuse.

Of the modern aqueducts in Rome the principal are the Aqua Felice, the Aqua Virginia, and the Aqua Paulina. The first was constructed by Sixtus V. It commences at Palæstrina, about twenty-two miles from the city, and discharges itself at the Fontana di Termini. The Aqua Paulina was repaired by Pope Paul V. in the year 1612. It divides itself into two principal channels, one of which supplies Mont Janiculum, and the other the Vatican and its neighbourhood. It is conveyed from the district of Bracciano, about twenty miles distant; and three of its five streams are not inferior to small rivers. According to the calculation of Prouy, these three aqueducts, with some additional sources, deliver in twenty-four hours 5,305,000 cubic feet. This, among a population of 130,000, gives about 40 cubic feet for each individual, which is nearly equal in proportion to the supply of ancient Rome in the period of its utmost splendour.

But the system of aqueducts was not confined to the capital of Rome. It was gradually extended throughout the provinces of that vast empire; and every city and considerable town had its conduits and aqueducts for supplying it with water, many of which still remain to attest the magnificence with which these works were carried on. In Plates XLVIII. and XLIX. we have given a view of some of these. The first is the remains of one of the principal aqueduct bridges in the aqueduct of Antioch. It is a work of great magnitude and height, but a very rude structure. The lower part consists almost entirely of solid wall, and the upper part of a series of arches with very massy pillars. It appears, however, to be a Roman work; and there are remains of another aqueduct on a lower level, and of an older date. The water to Antioch was brought from a distance of four or five miles, from a place called Battelma, which Pococke thinks was the very spot where Daphne stood. Several springs, one of which was so large as to turn several mills, were conveyed in channels of hewn stone, and united in one main stream, which was thence conveyed along the surface of the ground in a similar channel. Across all the rivulets and valleys it was raised on arches or aqueduct bridges, some of which are very lofty, and the principal is the one exhibited in the plate, extending upwards of 700 feet in length, and upwards of 200 feet high in the deepest part. From the remains of the aqueduct in the island of Mytilene, represented from Pococke in the same plate, this appears to have been also a magnificent work. It was built of gray marble rusticated. It is much superior in point of skill to the aqueduct of Antioch, the arches being carried in two ranges throughout the building. It extended about 500 feet in length, and was about 70 or 80 feet high at the deepest part.

The aqueduct or aqueduct bridge of Pyrgos, near Constantinople, forms a portion of the extensive hydraulic works with which that capital was supplied with water after it became the seat of empire. They are described by Andreossy in his voyage to the Black Sea, and account of the Thracian Bosphorus. It is a grand work, very remarkable both in design and execution, and affords a fair specimen of the style of such structures among the Romans in the middle ages. It consists of two branches, one of which only is seen in elevation in the plate; the other stood nearly at right angles to this, and is seen partly on the plan; it was hence called the Bended or Crooked Aqueduct, to distinguish it from another termed the Long Aqueduct, which was situated near the sources of the

waters. The branch seen in elevation extends 670 feet in length, and is 106 feet in height at the deepest part. It is composed of three rows of arches, those in each row increasing in width from the bottom to the top—an arrangement very properly introduced with the view of saving materials without diminishing the strength of the work. The two upper rows consisted of arches of semicircles, the lower of Gothic arches; and this circumstance serves to fix the date of the structure, as these last were not introduced until the 10th century. The breadth of the building at the base was 21 feet, and it diminished with a regular batter on each side to the top, where it was only 11 feet. The base also was protected by strong buttresses or counterforts, erected against each of the pillars. The other branch of the aqueduct was 300 feet long, and consisted of 12 semicircular arches.

This aqueduct serves to convey to Constantinople the waters of the valley of Belgrade, one of the principal sources from which the city is supplied. These are situated on the heights of Mount Hæmus, the extremity of the Balkan Mountains, which overhangs the Black Sea. The water rises about 15 miles from the city, and between three and four miles west of the village of Belgrade, in three sources, which run in three deep and very confined valleys. These unite a little below the village, and then are collected into a large reservoir. After flowing a mile or two from this reservoir, the waters are augmented by two other streams, and conveyed by a channel of stone to the Crooked Aqueduct. From this they are conveyed to another, which is the Long Aqueduct; and then, with various accessions, into a third, termed the Aqueduct of Justinian. From this they enter a vaulted conduit, which skirts the hills on the left side of the valley, and crosses a broad valley two miles below the Aqueduct of Justinian, by means of an aqueduct with a double row of arcades of a very beautiful construction. The conduit then proceeds onward in a circuitous route, till it reaches the reservoir of Egri Kapan, situated just without and on the walls of the city. From this they are conducted to the various quarters of the city, and also to the reservoir of St Sophia, which supplies the seraglio of the grand signior. The Long Aqueduct is more imposing by its extent than the Crooked one, but is far inferior in the regularity of design and disposition of the materials. It is evidently a work of the Turks. It consists of two rows of arcades, the lower being 48 in number, and the upper 50. The whole length was about 2200 feet, and the height 80 feet. The Aqueduct of Justinian is a very excellent work, and without doubt one of the finest monuments which remain to us of the middle ages. It consists of two rows of large arcades in the pointed style, with four arches in each. Those of the lower story have 52 feet of span, the upper ones 40 feet. The piers are supported by strong buttresses, and at different heights they have little arches passing through them, which relieve the deadness of the solid pillar. The length of this aqueduct is 720 feet, and the height 109 feet. This aqueduct, though it bears the name of Justinian, was probably erected in the time of Constantine.

Besides the waters of Belgrade, Constantinople was supplied from several other principal sources, one of which took its rise on the heights of the same mountains, three or four miles east of Belgrade. This was conveyed in a similar manner by an arched channel, elevated when it was necessary on aqueduct bridges, till it reached the northern parts of the city. It was in the course of this aqueduct that was constructed the contrivance of the *souterasi* or hydraulic obelisks described by Andreossy, and which has excited some attention, as being an improvement on the method of conducting water by aqueduct bridges. "The souterasi," says Andreossy, "are masses of masonry, having generally the form of a truncated pyramid or an Egyptian obelisk. To form a conduit with souterasi, we choose sources of water, the level of which is several feet higher than the reservoir by which it is to be distributed over the city. We bring the water from its sources in subterranean canals, slightly declining until we come to the borders of a valley or broken ground. We there raise on each side a souterasi, to which we adapt vertically leaden pipes of determinate diameters, placed parallel to the two opposite sides of the building. These pipes are disjoined at the upper part of the obelisk, which forms a sort of basin, with which the pipes are connected. The one permits the water to rise to the level from whence it had descended; by the other, the water descends from this level to the foot of the souterasi, where it enters another canal under ground, which conducts it to a second and to a third souterasi, where it rises and again descends, as at the last station. Here a reservoir receives it and distributes it in different directions by orifices of which the discharge is known." Again he says, "it requires but little attention to perceive that this system of conducting tubes is nothing but a series of syphons open at their upper part, and communicating with each other. The expense of a conduit by souterasi is estimated at only one fifth of that of an aqueduct with arcades." We really cannot perceive any advantage in these pyramids, further than as they serve the purpose of discharging the air which collects in the pipes. For if the water is to be conveyed in pipes across the valley, what other purpose can these columns possibly serve? They are in themselves an evident obstruction, and the water would flow more freely without any interruption of the kind. In regard to the leaden pipes, again, they would have required, with so little head pressure as is stated, to be used of very extraordinary dimensions to pass the same quantity of water as was discharged along the arched conduits. There is something, therefore, which would require explanation in this account of Andreossy regarding these pyramids, or else he has misunderstood the nature of them when he says that they supply advantageously the place of the aqueducts or arches. A train of pipes properly laid, and of proper dimensions, might do this; but what advantage the pyramids possess further than to answer the purpose of air-cocks, is not very apparent.

The other principal source from which Constantinople is supplied, is from the high grounds six or eight miles west of the town, from which it is conducted by conduits and arches, in the same manner as the others. The supply drawn from all these sources amounts, according to Andreossy, to 400,000 cubic feet per day; about two thirds of a foot to each person of a population of 600,000. The charge of the water-works at Constantinople belongs to a body of 300 Turks and 100 Albanese Greeks, who form almost an hereditary profession.

Of the aqueducts which still remain as relics of Roman grandeur, the most remarkable are, the aqueduct of Metz; the aqueduct of Nismes, or the Pont du Gard; and the aqueduct of Segovia in Spain. "The aqueducts of Rome," says Montfaucon, "were without doubt wonderful on account of their great length—arcades continued over the space of 40 or 50 miles; their great number, with which the Campagna of Rome was filled on every side: all this surprises us. But it must be confessed that if, without considering the total extent, we only look at any of the parts which remain round Rome, there is nothing that approached the aqueducts of Metz, of Nismes, or of Segovia." The aqueduct of Metz is represented in Plate XLIX. Nearly the half of it, it will be observed, has been carried away; but there still remain a great num-

ber of arches, and enough to give an idea of the extent of the whole. It extended across the Moselle, a very considerable river, and very broad in this place; and served to convey the delicious waters of the Gorse to the city of Metz. These waters, according to Meuripe, in his history of the bishops of Metz, printed in 1634, were so abundant that they furnished water for floating the vessels every time that a naval fight was to be exhibited. They were collected into a reservoir, and from thence conducted by subterraneous canals constructed of hewn stone, and so spacious that a man could easily walk in them upright. They then passed the Moselle by means of the aqueduct, which was situated about six miles from Metz, and from thence were conducted under ground in stone channels, similar to the others, to the city, to the baths, to the place of the sea-fight, and all over the city. Judging from the drawing, this aqueduct seems to have been nearly 1000 feet in length, the arches 50 feet high at the deepest part, and 50 in number. They formed only one series, the height not requiring a double row. They were so well built and cemented together, that, excepting the middle part, which the descent of ice down the river has in the lapse of ages carried away, they have resisted, and will continue to resist, the effects of time and of the most violent seasons.

The Pont du Gard was executed by the Romans in the reign of Augustus, and was then merely an aqueduct for bringing the waters of the fountain of Hure to Nismes. It was composed of three rows of arches filling up the valley between two mountains, between which ran the river Gardon. The first row comprehended six arches, each 60 feet span, excepting one, which was the largest, and was 75 feet span; the second row contained 12 arches of the same span as the first; and the third had 36 little arches, on the top of which was the channel for conducting the water. This bridge exhibits a decided improvement and superiority over all the other Roman aqueducts, in the lightness and striking boldness of its design. The arches are wider, and the piers in proportion lighter, than any other structure of the kind previously constructed; and had the same principle been extended so as to have formed only a single row from top to bottom, it would have equalled in the skill and disposition of its materials (circumstances in which the Roman works were almost universally wanting) any of the more judicious and elegant structures of modern times. About the year 1740, this bridge, being of no more use as an aqueduct, was converted into a road-way, by widening it, or rather building in a manner another bridge to the side of it, having all the arches of the same span and dimensions. The execution of the work was attended with considerable difficulties, but these were all successfully overcome by the French engineer Pitot.

The aqueduct of Segovia, according to Culmenares, who travelled in Spain, and has written the history of Segovia, may be compared with the most wonderful works which antiquity has transmitted to us. There still remain of it 159 arches, all built with large stones, and without any cement. There are two rows of arches, one above the other, and the whole height of the edifice is 102 feet. It runs quite across the town, and passes over the greater part of the houses which lie in the hollow.

In modern times various aqueducts have been formed after the manner of the Romans, particularly in France; and the most remarkable are those which have been constructed by Louis XIV., at vast expense, for conducting water from Versailles to Marli. Of these the famous aqueduct bridge of Maintenon, which was erected for conveying the waters of the river Eure to Versailles, is without doubt, in point of magnitude and height, the most magnificent structure of the kind in the world. In Plate XLIX. we have given a view of a portion of this work, on the same scale as the other aqueducts here represented. Had the whole been delineated on the same scale, it would have extended to four times the breadth of the plate. It extends about 4400 feet in length, being nearly seven eighths of a mile, and upwards of 200 feet in height, and contains 242 arcades, each divided into three rows, forming in all 726 arches about 50 feet span. Of the subterranean aqueducts in France the finest is that of Arcueil, which serves to conduct water to that village. It is 44,300 feet in length, or upwards of eight miles, extending from the valley of Arcueil to the castle at the gate of St Jaques, all built of hewn stone. It is about six feet in height, and has on each side a foot-path 18 inches wide; it has a declivity of one foot in 1300. Another aqueduct of this kind is that of Roequaneourt, part of the system which brings water to Versailles; it is 11,760 feet in length, or upwards of two miles, and a declivity in its whole course of only three feet. In some parts of its course it was necessary to make excavations 80 or 90 feet deep, which rendered the execution very difficult.

But in modern times, at least within the last century, the invention and improvement of the manufacture of cast iron has completely changed the mode of conducting water into cities, by the introduction of cast-iron pipes instead of the stone conduits of former times. These pipes can now be formed of almost any dimensions, and united together into a continued series, so closely as to prevent the escape of the water, even under a violent pressure arising from the altitude of the fountain-head. They enable us, therefore, to take advantage of and give effect to that grand principle in hydrostatics, that the fluid element tends continually to a level, even though it be confined in the smallest or most complicated system of pipes; so that however low it be carried in any valley, or to whatever distance, still it will rise on the opposite side to the original altitude of the fountain-head—a principle which is most important indeed in such works, seeing that by it we are not restricted, as the Romans were, almost to a perfect level in the line of the conduit. We have seen that, for the purpose of attaining this level or very gentle declivity all along the conduit, they were under the necessity of raising it by arcades continued in one unbroken series, frequently thirty or forty miles in extent; and, in addition to this, often prolonging the length of the track by a circuitous route, turning and winding for miles out of its course, for the very purpose of increasing its length.

But the use of pipes enables us to dispense with these long arcades all raised nearly to the same level with the fountain-head; because the conduit may be varied in its level to any extent, and still will rise at last to its original altitude. The pipes, therefore, are merely laid all along the surface of the ground, with a cover of two or three feet of soil to place them beyond the reach of frost. To prevent, however, the frequent or abrupt alternations of rise and fall, any sudden inequalities in the ground are equalised by cuttings and embankments, but not to any thing like the extent that would be required to raise the whole to a level. This, therefore, forms a capital improvement in the method of conducting water, and the greatest indeed which has ever been made in this important branch of practical mechanics. That it was not introduced by the Romans, is not to be ascribed, as many have done, to their ignorance of the hydrostatic principle, that the fluid would rise to a level in the opposite branches of the same train of pipes. Professor Leslie has shown that they were well acquainted with this principle, and has moreover obtained from Italy a portion of a leaden pipe supposed to have been used in the baths of Caracalla, which

sets this matter at rest. But, from the low state of the arts at that period, they were unable to give effect to the principle. They had not the means of fabricating pipes of such a magnitude as would have been required for the enormous quantities of water consumed in Rome, and at the same time of strength sufficient to withstand the pressure from the fountain-head. Lead was the only material that could be used by them for the purpose; and besides the enormous thickness that so weak a material would have required, and the impracticability of their forming them, and uniting them together endwise, they had a decided aversion to lead, as tending to make the water unwholesome by its poisonous impregnation. The use of cast iron was quite unknown. There remained, therefore, no resource but in the aqueducts, which, though attended no doubt with vast expense, and requiring great enterprise, as well as both skill and patience, were yet attainable by these means, and formed when completed a simple and very perfect mode of effecting the object. Hence arose all those works above described which have since excited such astonishment. Now, however, when the manufacture of cast iron has been brought to such perfection, and methods contrived for uniting perfectly together all the pipes into one connected train, this improved system has been universally adopted.

The most complete and perfect works of the kind are those some time ago undertaken for the supply of Edinburgh, which, by the contrivance and direction of Mr Jardine, the company's engineer, have been executed in a style quite worthy of the city, as well as of the present advanced state of science and the arts; offering, both in the general design and in all the details, a model of propriety and skill in this species of hydraulic architecture. The Crawley Spring, from which the new supply has been derived, issues from the side of a rising ground on the southern base of one of the Pentland Hills. It is scarcely seven miles distant from Edinburgh in a straight line, but eight and three fourths in the line of the pipes, these having been carried round a considerable way to the eastward to avoid the Pentland ridge, the eastern extremity of which lies in the direct line to the city. The spring is elevated 564 feet above the level of the sea, and 360 above the level of Princes Street. There is therefore ample height to carry it over the highest parts of the town. The original issue of the spring was greatly augmented by a drain, which was carried for about half a mile above the spring, up the valley in which it is situated. The soil of this valley, consisting of an immense bed of gravel, in many parts 40 feet deep, constitutes a vast natural filter, through which the water, descending from the high grounds on each side of the valley, percolates in a high degree of purity, and being all intercepted by the drain, is by it conducted, along with all the original discharge of the spring, into a reservoir or water-house, from which the pipes take their rise, and continue in one connected train all the way to the city. In the first three miles they vary from 18 to 20 inches diameter, and descend 65 feet in a pretty regular series. In the remainder of the track they are 15 inches diameter, and descend 286 feet. The descent is not perfectly regular, being in some parts steeper than in others, according to the natural declivity of the country. In one or two instances also they undulate slightly. Near Burdiehouse, four miles from the city, they ascend a little; and, after descending rapidly to Libberton Dams, they again ascend 20 or 30 feet to the high ground on the south side of the Meadows. There are, however, no sudden inequalities, all such having been carefully avoided by levelling; for which purpose considerable embankments and cuttings of the ground have been undertaken without scruple; and as the line approaches the city, it has been carried through a tunnel 2160 feet in length under Heriot's Green, about 70 or 80 feet below the surface, and another under the Castlehill 740 feet through the solid rock, and 120 feet under the reservoir. From this main line of aqueduct a branch pipe leads off on the south side of the town to the Reservoir at Heriot's Green, near Heriot's Hospital, which aids the former source in supplying fully the southern districts; a second leads off from the same place to the eastward, and affords an additional supply to the south side of the town, directly from the pipes; and a third leads off to the Reservoir on the Castlehill, and aids it in supplying the rest of the old town. The main body of the water, however, proceeds onwards to Princes Street, along Hanover Street, and across Queen Street; and from thence branch pipes are laid through all the other streets in the new town, and from these again service pipes to each house or floor of a house. Each pipe in this aqueduct is about nine feet in length, the metal being about half an inch thick. After being cast, their soundness was proved by a forcing pump applied to each separately, and with a gage-valve loaded with a weight equivalent to a pressure of 800 feet; and if under this they betrayed the smallest flaw, they were rejected. They are all joined together with what is termed spigot and faucet joint, the end of the one being let several inches into a swelled part or socket at the extremity of the other. This forms a much more perfect joint than by flanches and bolts, as it admits of a slight degree of expansion in the pipes without opening the joining. After being entered, a ring of hemp or rope-yarn is wrapped round the end of the pipe and beat into the socket of the other, and then a mass of lead run in to fill up the opening, which the yarn prevents from running into the pipe: the lead being hard rammed, and stoved with a chisel, forms a joining completely water-tight. Air-cocks are placed at intervals all along the pipes to let off the accumulated air, which is done by the hand at regular intervals, perhaps every three or four days. The supply of water now conveyed by this aqueduct amounts to 180 or 200 cubic feet per minute at an average. This is about five times the quantity formerly delivered into the town by all the different ponds and reservoirs from which it was then supplied, and which was besides often of a very impure and unwholesome quality. The introduction of this spring therefore gave, as may easily be conceived, wonderful relief to the inhabitants, and is now found, along with the former sources, amply sufficient for every purpose of comfort or luxury. The Crawley aqueduct, however, is capable of conveying double this quantity whenever the wants of the city shall render necessary a new supply, which it is in that case intended by the present company to draw from another excellent and copious spring termed the Black Spring, situated on the north side of the Pentland Hills. The whole expense incurred by the Joint-Stock Water Company in bringing in the Crawley water, including the expense of the great compensation reservoir for supplying the deficiency to the mills on the stream from which the Crawley was diverted, amounted to about L.145,000, and the company draw an assessment on every consumer of five per cent. on the rental of his premises, which is understood to yield L.6000 or L.7000 a year. They are allowed to divide to the amount of six and a half per cent. on their capital, but not more.

The water from the Crawley Spring is naturally of the finest quality; and issuing continually from a source deeply seated in the ground, and also at so great an altitude, is always fresh and cool, even in the heat of summer, provided it is not allowed to stagnate in our cisterns. In this respect the supply of Edinburgh is far superior to that of

Aqueduct.

most other towns of the same magnitude. In Glasgow, for example, the supply is sufficiently ample; but being derived all from the Clyde, it is liable to become warm and unpleasant in summer. In Liverpool, Manchester, and even in London, the supplies, though abundant, are liable to the same defects. So that on the whole we have reason to congratulate ourselves that the elevated nature of the country round our city affords sources for a supply so copious, so pure, and capable of reaching so easily, and without the aid of any machinery, the highest parts of the town.

In all places such as the above, where there is a deficiency of level to carry the water naturally to the highest parts of the town, there is no resource but in the employment of machinery. A steam-engine or other agent is applied to the working of pumps, which both draw the water from the rivers or from wells, and then propel it by force through a train of pipes to all the different parts of the town, and elevate it by branches to the highest parts that may be necessary; a plan which we believe is now executing at Aberdeen, and also at Perth.

Aqueduct bridges or canals.

But though the system of pipes has thus superseded the use of stone channels all raised to a level in the conveyance of water, there are still cases, such as those of canals, where the water must be kept on a perfect level, and where, therefore, aqueduct bridges are still necessary in conveying it over the valleys; and of these we have long had examples in France, on the Languedoc canal. The first aqueduct bridges for canals in this country were those made by the Duke of Bridgewater, under the direction of the celebrated Brindley, and which, being quite new here, excited no small degree of astonishment. The first and largest was the aqueduct at Barton Bridge for conveying the canal across the Irwell, 39 feet above the surface of the water. It consisted of three arches, the middle one 63 feet span, and admitting under it the largest barges navigating the Irwell with sails set. It was commenced in September 1760; and in July of the following year the spectacle was first presented in this country, of vessels floating and sailing across the course of the river, while others in the river itself were passing under them. Since that period canal aqueducts have become more common; and many excellent examples are to be found both in England and Scotland. Of these are the aqueducts over the river Lune, on the Lancaster canal, designed by Rennie, a very excellent and splendid work of five arches, each 72 feet span, and rising 65 feet above the level of the river; and the Kelvin aqueduct, near Glasgow, which conveys the Forth and Clyde canal over the valley of Kelvin, consisting of four arches, each 70 feet span, and rising 70 feet above the level of the river. In Plate XLIX. we have given views of three other principal aqueducts, viz. the aqueducts of Pont Cysylte, of Chirk, and of Slateford near Edinburgh. Of these the Pont Cysylte by Mr Telford is justly celebrated for its magnitude, for the simplicity of the design, and the skilful disposition of the parts, combining lightness with strength in a degree seldom attempted. This aqueduct serves to convey the waters of the Ellesmere canal across the Dee and the vale of Llangollen, which it traverses. The channel for the water is made of cast iron, supported on cast iron ribs or arches, and these resting on pillars of stone. The iron being much lighter than stone arches, this is one reason why the pillars have been reduced apparently to such slender dimensions. They are quite strong enough, however, as experience has proved. The whole length of the aqueduct is about 1000 feet, and consists of 19 arches, each 45 feet span. The breadth of the pillars at the top is 8 feet, and the height of the four middle ones is 115 feet to the springing. The pillars have a slight taper, the breadth of the middle ones at the base being 15 feet. The height from the surface of the water in the Dee to that in the canal was to be 126 feet eight inches. The channel for the water consists of cast iron plates, cast with flanches, and these screwed together with bolts; they are represented in the drawing, between the arched ribs and the railing. The lines there show the joinings of the different plates. In order to preserve as much water-way as possible, the channel is made the full width of the canal and towing path, and the latter projected over one side, and supported inside by posts resting on the bottom of the canal. The aqueduct of Chirk was designed by the same able engineer, and serves also to convey across a valley the waters of the same canal. This aqueduct was the first in which any iron was employed. Hitherto the channel for the waters had been constructed of stone, or partly of stone and partly of clay puddle, which it was generally found very difficult to keep water-tight for a length of time. It was determined, therefore, by Mr Telford to try the effect of cast iron, and to lay it at first only in the bottom. The plates were accordingly laid directly over the sprandril walls, which they served to bind together, and united by flanches and screws. The sides of the channel were built with stone facings and brick hearting laid in water-lime mortar. This plan has succeeded completely, and the quantity of masonry in the aqueduct was thereby greatly reduced. The aqueduct itself is 600 feet long, and 65 feet high above the river, consisting of ten arches, each 42 feet span. The piers are ten feet thick.

The aqueduct of Slateford serves for conveying the waters of the Edinburgh and Glasgow Union Canal across the valley of the Water of Leith at Slateford. It is an elegant structure, and very similar in the plan to that of Chirk, only that the water-channel is composed entirely, the sides as well as the bottom, of cast iron, which is moreover built in with masonry. It is about 500 feet in length, and consists of eight arches, each 45 feet span; and the height of the canal is about 70 feet above the level of the river. On this canal another aqueduct of the very same construction occurs in crossing the valley of the Almond, and having several more arches. There are, in different parts of the country, various other aqueducts, which might be described; but our limits preclude our enlarging upon them; and it is the less necessary, as, excepting the formation of the water-way, these structures differ nothing in their design or the principle of their construction from ordinary bridges, particularly those that are undertaken not so much with the view of crossing rivers as of raising up the level of the road itself entirely out of the valley,—an object now become of great importance, from the improvements which have taken place within the last half-century on all our roads, and the refined notions which have in consequence begun to prevail as to the rates of travelling, and, what conduces most essentially to this object, the levels of the road. Formerly people were content to traverse slowly all the inequalities of the country through which the road might pass, descending into the valleys, and mounting the steepest acclivities. Now, however, a road is thought imperfect, and quite behind the standard of improvement, unless every rise greater than 1 in 15 or 1 in 20 feet be cut down. In crossing the valleys, therefore, it is not enough now that we build a bridge in all respects sufficient for crossing the stream itself; we must raise it nearly to a level with the ground on each side of the valley; and this circumstance gives rise to new and very extensive works of this kind, which formerly never would have been thought of. Of these we may just instance the splendid bridge of one arch of 140 feet span, built over the Den Burn at Aberdeen, to form a new access into that town;

also the beautiful bridge of Cartland Craigs, built by Mr Telford, over the little stream of the Mouse, on the new road from Glasgow to Carlisle, consisting of three arches 50 feet span, and elevated 130 feet above the bed of the stream. More recently (for in this important department of our domestic economy, which regards the perfecting of the interior communications of the country, improvements seem to be going on, not merely with rapidity, but with an accelerated progression which it is quite wonderful to contemplate) the introduction of railways opens a new and still wider field for the skill and talents of the engineer in the erection of such works. This new and improved species of road, it is well known, must be kept still more nearly on a level than any of the roads of the ordinary construction. Considerable inequalities in these may still be tolerated, but in the railroad they are quite inadmissible, and would defeat the very object of the improvement. (See RAILWAY.) In this respect the railway is somewhat similar to the old Roman aqueducts, and, where the country is low, must in like manner be elevated on a series of arcades. These sort of bridges have received the name of *Viaducts;* and already we have an extensive one on the Liverpool and Manchester railway, termed the Sankey Viaduct, of nine arches; and numerous others will no doubt be speedily required. But for the principles and mode of construction of these works, as well as of the aqueduct bridges, so far as the arch is concerned, we refer to the articles ARCH and BRIDGE; and for further information on the subject of aqueducts, see Julius Frontinus, *De Aquæductibus Urbis Romæ;* Raphaelis Fabretti *De Aquis et Aquæductibus Veteris Romæ Dissertatio;* Famiani Nardini *Roma Vetus*, lib. viii. cap. iv.; Plinii *Hist. Nat.* lib. xxxvi. cap. xv.; Montfaucon, *Antiquité Expliquée*, tome iv. tab. 128; Governor Pownall's *Notes and Description of Antiquities in the Provincia Romana of Gaul;* Belidor's *Architecture Hydraulique*, containing a drawing of the aqueduct of Maintenon; also *Mém. Acad. Par.;* Andreossy, *Voyage à l'Embouchure de la Mer Noire, ou Essai sur le Bosphore; Philosophical Transactions Abridged*, vol. i.; and Link's *Travels in Portugal.* (C.)

AQUILA, or AQUILA and ANTINOUS, the EAGLE, in *Astronomy*, a constellation of the northern hemisphere, usually joined with Antinous. In Bode's description of the constellations Aquila contains 276 stars, four of which are double, and three nebulous.

AQUILA, a city of the kingdom of Naples, and chief of the province Abruzzo Ulteriore Second. It is situated on the Aterno, in the vale of Aquila and Pescara. It has no less than 24 parish and 29 monastic churches, besides the cathedral, though the population in 1818 amounted only to 7525 persons. There are some manufactures of linen and paper, and some trade in corn, cattle, saffron, and the other products of the vicinity. Long. 14. 5. 47. E. Lat. 42. 25. N.

AQUILICIUM, or AQUILICIANA, in *Roman Antiquity*, sacrifices performed in times of excessive drought, to obtain rain of the gods.

AQUILUS, among the ancients, a dark or dusky colour approaching to black. Hence some of the heathen gods were called *dii aquili*, q. d. *nigri.*

AQUIMINARIUM, in *Antiquity*, a kind of lustral vessels, wherein the Romans carried their holy water for expiation and other religious offices.

AQUINAS, ST THOMAS, styled the *Angelical Doctor*, was of the ancient and noble family of the counts of Aquino, descended from the kings of Sicily and Arragon; and was born in the castle of Aquino, in the Terra di Lavora in Italy, in the year 1224 or 1225. He entered into the order of the Dominicans; and, after having taught school divinity in most of the universities of Italy, at last settled at Naples, where he spent the rest of his life in study, in reading lectures, and in acts of piety; and was so far from views of ambition or profit, that he refused the archbishopric of that city, when it was offered him by Pope Clement IV. He died in 1274, leaving an amazing number of writings, which were printed at Venice in 17 vols. folio, in the year 1490. He was canonized by Pope John XXII. in the year 1323; and Pius V. who was of the same order with him, gave him, in 1567, the title of the Fifth Doctor of the church, and appointed his festival to be kept with the same solemnity as those of the other four doctors. His authority has always been great in the schools of the Roman Catholics. Lord Herbert, in his life of Henry VIII., tells us that one of the principal reasons which induced that king to write against Luther was, that the latter had spoken contemptuously of Thomas Aquinas.

AQUINO, a town of Italy, in the kingdom of Naples, and Terra di Lavora; a bishop's see, but ruined by the emperor Conrade, and now consisting of about 35 houses. It was the birthplace of the poet Juvenal, and of Thomas Aquinas. Long. 14. 30. E. Lat. 41. 32. N.

ARA, or ARA THURIBULI, the altar of incense, in *Astronomy*, a southern constellation, not visible in our horizon. It consists, according to Bode, of 81 stars.

ARABESQUE, or ARABESK, something done after the manner of the Arabians. *Arabesque, Grotesque*, and *Moresque*, are terms applied to paintings and ornaments where there are no human or animal figures, but which consist wholly of foliages, plants, stalks, &c. The words take their rise from hence, that the Moors, Arabs, and other Mahometans, use these kinds of ornaments; their religion forbidding them to make any images or figures of men or other animals.

ARABIA.

THIS extensive country, which is situated at the south-western extremity of Asia, has been famed in all ages for freedom and independence; for the peculiar character and manners of its rude tribes; and for the wild and interesting aspect of its interior deserts, contrasted with the fertility of other tracts, of which the rare and precious products have always formed the staple articles of the Arabian trade. It has been distinguished in history as the scene of great events, and especially of that wonderful revolution in religion, under the influence of which the Arabs, inflamed with the spirit of proselytism and of conquest, spread their victorious arms over the fairest portions of the earth, and brought about not merely the downfall of empires, but a revolution of opinion and manners which gradually extended over the greater portion of Africa, and over the eastern world from Constantinople to the frontiers of China.

Boundaries.

Arabia is a peninsula, stretching north-west and south-east. It has the form of an irregular triangle, and is inclosed on three sides by the ocean. It is bounded on the south-west by the Red Sea and the Isthmus of Suez; on the north-east by the Persian Gulf and the lower course of the Euphrates; on the north-west by Syria, the Euphrates, and the intervening desert; and on the south-east by the Indian Ocean. Its length from this ocean to the frontiers of Syria is about 1430 miles, and its breadth

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from the Isthmus of Suez to Bassora about 700. The peninsula enlarges in breadth as it approaches the Indian Ocean, the southern basis of the triangle; and from the Straits of Babelmandib to the Persian Gulf its extent cannot be less than 1000 miles. The division of this country by the ancients was, according to the natural qualities of the soil, into Arabia Petræa, or the Stony, Arabia Deserta, and Arabia Felix. No very distinct boundary was assigned to these divisions. Under Arabia Petræa was included that barren and rocky tract in the north-west of Arabia which is situated between the northern shores of the Red Sea and the Mediterranean, and which may have extended southwards nearly to Mecca. Arabia Deserta was separated on the north by the Euphrates from Mesopotamia; on the west it was bounded by Syria, Judea, and Arabia Petræa; on the east and south it was separated from Chaldea and Arabia Felix by ridges of mountains. Arabia Felix was bounded on the north by Arabia Petræa and Arabia Deserta, on the south by the Indian Ocean, and on the east and west by the Persian Gulf and the Red Sea. The modern division of the country is entirely different, and if possible more indistinct. It does not appear that the eastern geographers are either agreed as to the divisions of the country, or as to the limits of those divisions. By some the whole country is divided into two parts, namely, Yemen and Hedjaz; while others will have it divided into the five great provinces of Yemen, Hedjaz, Nedjed, Tehama, and Yemama. Others, again, adopt a different division, into six or seven parts; and Hadramaut, Mahrah, Shejr, Oman, and other subdivisions, have been raised to the rank of independent provinces; while, according to a different hypothesis, they are held to form a part of the lower provinces of Yemen and Hedjaz. Niebuhr adopts the division into six provinces; but, along with other geographers of eminence, he includes Arabia Petræa in the Hedjaz, which is erroneous, and is inconsistent with the more correct geography of modern travellers.[1] Those divisions of the country, which are purely arbitrary, are noway essential to accuracy of description. The following, therefore, may be given as the modern divisions. Arabia Petræa, the Hedjaz, Tehama, and Yemen, comprehend the western portion of the peninsula, including the range of mountains that extend from the Mediterranean along the coast of the Red Sea as far as the Indian Ocean. The province of Yemen lies along the coast of this ocean. To the east are the provinces of Hadramaut and Oman, which last is at the entrance of the Persian Gulf, and is washed by it; while on the north-east the province of Lahsa or Hajar is on its western shore. These provinces encircle the central deserts, which are partly included in the extensive province of Nedjed.

Aspect of the country.

Arabia may be generally described as a vast collection of rocky and precipitous mountains, encircled by a border of low, barren, and sandy plains. On all the sides on which it is washed by the Red Sea, the Indian Ocean, and the Persian Gulf, it is bounded by these plains, which extend from the sea-shore 100 or 200 miles into the interior as far as the hills; and towards the north the extensive plain is formed by the vast deserts which extend to Syria and over Arabia Petræa; while to the south, as far as the mountains which overlook the Indian Ocean, the intervening country, judging from the imperfect accounts of travellers, forms one extensive and continued desert. The plains and mountainous districts differ widely in their climate, soil, and productions.

The great characteristic of those vast tracts of desert, which frequently extend on a dead level for several hundred miles, is aridity, and its necessary consequence, barrenness. They consist either of bare rocks or of hard or loose sand, and are almost destitute of fresh water. There is no eminence to arrest the clouds as they pass along the plain, and whole years frequently pass away without rain. The drought is consequently extreme; vegetation withers under the fierce influence of a scorching sun; and the burning sands, reflecting the solar rays, occasion such intense heat as is not felt even in countries that lie directly under the equator. There are no rivers, the mountain torrents being speedily imbibed by the sandy soil; and the scanty supplies afforded by deep wells and springs, scattered at distant intervals, are the sole dependence of the fainting traveller for refreshment, and frequently for life. Without this resource these deserts must have for ever remained impervious to man. The aspect of desolation is sometimes relieved by verdant spots, which appear like islands in the trackless ocean; and some rare and hardy plants, such as the tamarind and the acacia, which strike their roots into the clefts of the rocks, find here a congenial soil, and flourish amid the surrounding waste.

In the Arabian plains the thermometer is generally above 100° during the night, at 108° in the morning, and in the course of the day it rises to 110°, and sometimes higher in the coolest and shadiest parts. All travellers who have visited the coasts of the Red Sea appear to have been oppressed by the extraordinary heat, and to have considered the temperature of other tropical countries as moderate in comparison. The sultriness of the nights is another peculiar evil of the Arabian climate, and a predisposing cause of disease.[2] For this peculiarity the country is partly indebted to its position, hemmed in between the continents of Asia and Africa, and effectually protected by the latter from the influence of the south-west monsoon, which blows during the summer on the coasts of India, and ushers in the periodical rains. Arabia never experiences the refreshing influence of this wind. It seems to blow exactly along its south-eastern shore, on which baffling winds prevail, or a dead calm.[3] During the whole summer the heat in the lower plains on the coast is so steady and equable that the atmosphere remains in a state of repose. No change of temperature takes place to set the winds in motion; and dead calms occur, and sometimes continue for sixty days without interruption. When the temperature begins to vary with the change of the seasons, and the winds resume their activity, the country is visited by the simoom or the hot blast from the deserts, under whose withering influence all nature seems to languish and expire,—which has the quality of extracting from whatever it touches every trace of moisture, and to produce, when it is inhaled by men or animals, a painful feeling, as of suffocation. But though its effects are pernicious to health, they have been greatly exaggerated by credulous or ill-informed travellers; and among others Niebuhr, to whom we are indebted for much valuable information respecting Arabia, ascribes to it the power of

[1] See *Travels in Arabia*, by J. Lewis Burckhardt. *Preface of the Editor.*

[2] Fraser's *Narrative of a Journey into Khorassan*, chap. i. Climate of Oman.

[3] It is mentioned by Fraser, in the account which he gives of a *Voyage from Bombay to Mascat*, in the Persian Gulf, that the moment they doubled Cape Rassel Gate, a corruption of Raus-ul-Hud, literally land's end, and entered the Persian Gulf under the lee of the Arabian land, they were forsaken by the south-west monsoon, and encountered baffling winds or calms until they arrived at Mascat, which is about 120 miles up the Gulf.

suffocating any living creature that is exposed to its influence. Others imagine that it has poisonous qualities. It appears, however, from the accounts of various travellers, and among others of Mr Buckingham, that its effects are produced solely by heat. When it is suddenly inhaled, it may, in the same manner as a hot blast from an oven, cause faintishness or sickness, and even swooning; but this feeling is occasioned wholly by the heat and parching qualities which it contracts in its passage across the burning sands. The desert consists in many parts of loose sand, interspersed with sharp and naked rocks; and the effect of these violent winds is to raise up in clouds this fine sand, and to set it afloat in the atmosphere in such quantities that it is impossible to see to the distance of a few yards. On such occasions, during the violence of these sand storms, it is the practice of camels and other animals to lie down by instinct, and bury their nostrils under the sand, to avoid the influence of the wind. In this situation the traveller generally lies down on the lee side of the camel, and in a short time the sand is blown up to the level of the animal, which has accordingly to rise and to lie down on a new foundation, in order to avoid being entirely covered. But in many cases, from weariness, faintness, or sleepiness, occasioned by the great heat, and often from a feeling of despair, both the man and the animal remain on the ground, and in twenty minutes they are buried under a load of sand, and perish miserably in those inhospitable deserts. The approach of the simoom wind is indicated by an unusual redness in the sky, which during the prevalence of the wind seems to be all on fire.

But though a large proportion of Arabia consists of arid and burning deserts, the country immediately behind the dry and sandy plains, which stretches backwards from the sea-shore, rises into rocky and precipitous hills, with intervening valleys of remarkable fertility. Those mountainous tracts, which send forth ridges into the interior in various directions, enjoy a temperate climate; and in some parts snow has been even known to fall, though it does not lie on the ground. Near Sana, about 200 miles north-east of Mocha, Niebuhr was informed that ice had been seen.[1] All these interior and highland districts are occasionally refreshed by copious rains, though they do not lie within the range of the monsoons, which in the peninsula of Hindostan usher in the rainy season. Those rains occur at different times of the year, according to the position of the mountains. On the western declivity of the mountains of Yemen, along the shore of the Red Sea, they commence in June and terminate in September, which is the season of the monsoons in India. This tract is also refreshed by a spring rain, while on the eastern declivity of the same mountains the season of the rains is between the middle of November and the middle of February. In Hadramaut and Oman, along the shores of the Indian Ocean and the Persian Gulf, the rainy season lasts from the middle of February to the middle of April; and the interior deserts have their winter rains, which occasionally fail, and leave the country a prey to severe drought. The prevailing wind in summer is from the west. The *simoom*, by which name the Arabs distinguish every hot wind, comes from the east. The south is reckoned favourable to vegetation; while the influence of the north wind, whether it be hot or cold, is always thought to be pernicious to the health both of man and beast. It is occasionally so sultry that it heats metals in the shade as if they were exposed to the sun. On the Persian Gulf the south-east wind is common, and is accompanied with moisture, which, when the heat is intense, occasions violent sweatings, and is even more injurious to health than the hot and dry blast from the northern desert. No traveller has given any accurate measurement of the height of the Arabian mountains; but the decided change of climate which takes place in these upland regions marks a considerable elevation above the adjacent plains.

Soil.

Among the Arabian highlands great diversities of soil prevail; and the craggy precipitous form of the hills is unfavourable to fertility. They afford neither sufficient space nor soil for vegetable productions, and the earth is continually washed away by the torrents. In many parts the rocks are basaltic in their form, and so steep that the road ascends by regular steps cut in the rock. These mountainous tracts are in general well cultivated and productive, especially the southern and mountainous provinces of Yemen and Hadramaut. This was the celebrated region of Arabia Felix, which, contrasted with the adjacent deserts, might deserve that appellation, being a fertile country, yielding the far-famed productions of balm and frankincense, and many sweet-scented trees and shrubs, of which the delicious fragrance, according to the descriptions of poets, was wafted by the winds over the surrounding seas. The mountains of Hedjaz and Yemen, which run along the eastern shore of the Red Sea, are precipitous and often rocky; but water abounds in wells, springs, and rivulets. This entire tract of country is well peopled as far as the mountains which overlook the Indian Ocean, and contains numerous villages of the Arab tribes. In all parts where water is near, and can be artificially spread over the ground, trees and inclosed fields are found; and among the rugged and basaltic mountains extensive and well-watered valleys, which to the south and the east are covered with the herds and flocks of the Bedouin Arabs, and to the north and west, towards the Red Sea, with industrious cultivators, who have relinquished their vagrant habits, and live in houses. In these valleys, which are frequently separated by intervals of barren rock, and the passes or entrances into which, through the mountains, are so narrow that they scarcely allow two camels to walk abreast, the villages are embellished with gardens, palm-groves, and date-trees, the fruit of which forms in many districts the staple article of the agriculturist; and with extensive plantations of coffee, which, when in flower, exhale an exquisite perfume. In many parts of Yemen whole mountains of basaltic columns are seen, which are rendered subservient to many useful purposes. Being easily separated, and formed into steps, they facilitate the ascent of the heights where it is difficult; and they supply materials for walls to support the plantations of coffee-trees on the steep declivities of the mountains.

The country between the mountains of the Hedjaz and the Red Sea is part of that narrow belt of sand which encircles Arabia. It is called Tehama, the appellation given to all the low plains on the coast, which are generally barren, having fewer fertile spots and more scanty pasturage than the mountains, where rain is more common.[2] Of the regions which are washed by the Indian Ocean and the Persian Gulf we have no full or accurate information. We know, however, that they are skirted by sandy plains similar to those on the western shore. The country which overlooks the Persian Gulf at Mascat has an extremely desolate appearance, consisting merely of sands, and naked rocks blackened by the scorching rays of the sun. It rises into mountains, which may be seen from the sea, and probably attain an elevation of from 1500 to 2000 feet.[3] These mountainous tracts are

[1] Niebuhr, vol. ii. chap. ii. sect. 28.
[2] Burckhardt's *Travels in Arabia*, vol. ii. Appendix, p. 377.
[3] Fraser's *Journey into Khorassan*. Description of Mascat.

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but little known; but it does not appear that they differ in their aspect, produce, or the manners of the inhabitants, from the corresponding tracts on the western shore. The province of Hadramaut, which lies along the shore of the Indian Ocean to the east of Yemen, was described to Niebuhr by a native. It is bordered by a sandy plain towards the ocean; but the hilly country from the coast, though in some places dry and desert, is intersected by well-watered vales. The hilly parts of Oman, which is to the east of Hadramaut, along the lower shores of the Persian Gulf, produce grain and fruits. The mountainous tract of Hassa, or El Ahsa, to the south, along the upper shores of the Persian Gulf, which is somewhat better known, extends about two days' journey in a direction parallel with the sea coast, and is about 35 miles broad. It is celebrated for its numerous wells, which enable the Arab tribes to cultivate clover, with which they rear a breed of excellent horses. This district contains the populous and walled town of El Hassa, the residence of some wealthy merchants, and one of the principal strongholds of the Wahaby sect. Akyr, the sea-port of El Hassa, is much frequented by Arab pirates. The territory contains, besides, about 20 villages, inhabited by the Bedouin Arabs.

Arabia appears to be divided by the ridges which branch out from these mountains through the interior, into the great northern and southern deserts. The first extends from the mountains eastward to the Euphrates, and northward to the frontiers of Syria and Damascus, and is intersected by the caravan routes to Syria and Egypt, along the western range of mountains, and to Bagdad eastward across the country from Mecca. The direct route to Syria, which is the route of the pilgrim caravan, is over a rugged country, through some very narrow defiles. Sometimes a few Bedouin merchants take camel-loads of coffee-beans by this route to Damascus. But it is not much frequented, being infested by strolling parties of the Arabs, who descend from the western mountains and rob the passing traveller in the plains. Seven days' journey north of Medina is the small district of Hedjer, watered by many wells and a running stream, where are large encampments of the Bedouins. In a mountain which bounds this fertile plain on the west are large caves or habitations cut out of the rock, with sculptured figures of men and animals, and small pillars, on both sides of the entrances. There is a continued line of small towns or Arab settlements from Medina across the northern desert to the Euphrates, which appear like islands in the wide waste by which they are surrounded. These settlements are the abode of Bedouin cultivators, or of petty merchants, who supply their wandering brethren in the desert with goods, which they purchase in the Syrian and Arabian towns, and form an intermediate class between the vagrant tribes and the peasants. There is, besides the routes already mentioned, a caravan route which passes northward to Syria from the hilly and the central districts of the interior, through the province of Djebel Shammar, more commonly called El Djebel, which is a mountainous tract between 400 and 500 miles east-north-east of Medina. The route through this district is in many parts over deep sand; and there is one stage of four days over a tract entirely destitute of water, which does not happen in any of the other routes across the desert, these being often, by a long circuit, brought near to the wells and springs. Here, as well as in the province of Nedjed, palm-trees are cultivated by means of water drawn up by camels from deep wells in leathern buckets.

The northern is divided from the southern desert of Arabia by the central province of Nedjed, which is east of Medina about 200 miles. The name, in opposition to Tehama, or "lowlands," signifies high or elevated ground. This province is an oblong tract extending between three or four journeys from west to east, and two journeys in breadth from south to north. Of all the interior provinces of Arabia it is the most fertile and populous, and is situated in the centre of the country. It contains 26 small towns or villages; and it produces corn, barley, fruits, and luxuriant pasturage, which abounds even in the deserts after rain, and affords subsistence to the wandering Arabs and their flocks, after they have consumed the herbage and water of less fertile districts. On its fine pastures is reared an excellent breed of camels, which are exported not only to the western province of Hedjaz, but to Syria and Yemen. The breed of horses is equally excellent, and so highly prized, that the finest Arabian horses are denominated Nedjed horses. Irrigation is a great aid of Arabian agriculture, in this as in all the other provinces; and there are numerous wells of great antiquity, and generally of the depth of from 25 to 30 fathoms. They are lined with stone, and are ascribed by the inhabitants to a primeval race of giants. They are mostly the property of individuals, who exact payment for the supplies which they furnish. The greatest evil to which this province is exposed is a failure of rain, which occurs every three or four years, bringing along with it scarcity and disease. Nedjed is occupied by Bedouin Arabs who do not emigrate, and by settlers who often travel as merchants to Damascus, Bagdad, Medina, Mecca, and Yemen. The people generally have a true commercial spirit: they are wealthy, and have a better character for honesty than most of the eastern traders. They are all armed with matchlocks, and every family manufactures gunpowder for domestic use. In this remote district the Arab manners have never been corrupted by any intercourse with strangers; for, excepting the pilgrim caravan from Bagdad to Mecca, none ever visit the country. Derayeh, east by south from Medina, is the capital. It is situated in a valley, which is approached by a defile so narrow as to afford access only to a single camel at a time. It has always been a place of note. Before the overthrow of the Wahabys it was the capital of the state, and contributed to the Wahaby armies a quota of 3000 soldiers armed with matchlocks. Ancyzy, 100 miles to the north-west of Derayeh, contains 3000 houses: it is furnished with bazars, and is inhabited by respectable Arab merchants.[1]

The central desert in Southern Arabia is perhaps one of the most dreary regions on the face of the earth. It has the province of Nedjed on the north, that of Hadramaut on the south, and extends eastward from the western ridge of mountains to the frontier of Oman, comprising a space of 600 or 700 miles each way. It is called by the Bedouins *Roba el Khaly*, "the empty or deserted abode." This vast expanse of desolation is entirely destitute of wells, and the only supply of water is from the rains. During the absence of rain in summer the country is one continued tract of burning sands, and is entirely deserted. When these sands are refreshed by the winter rains they produce herbage, to which the pastoral tribes of Nedjed, Hedjaz, and Yemen resort with their flocks. But the depths of this frightful wilderness have never been fathomed, and many parts, especially towards the east, exhibit no trace of vegetation. One single station, the Wady Djebryn, through which passes the route from Nedjed to the southern province of Hadramaut, di

[1] Burckhardt's *Travels in Arabia*, vol. ii. Appendix.

versifies the solitary tract. It has wells and date-trees, but from its noxious climate is uninhabited.

Arabia, from its diversified surface, contains within its bounds the climates and the vegetable produce of different countries. The mountainous tracts yield in great abundance wheat, barley, and an inferior species of grain called *durra;* also the fruits of Europe in equal variety and perfection, such as figs, apricots, peaches, apples, almonds, pomegranates, grapes of the very best quality, and excellent dates, which in many parts are the chief food of the inhabitants, as well as an article of export. Many of the fine fruits of India have been transported thither, and are now naturalized. Such are the banana tree, the mangoustan, the Indian palm, and the Indian fig-tree. Besides the European grains it yields abundantly rice and maize. In the highland provinces forests are sometimes seen, which contain many trees little known, or differing extremely from the same genera in northern countries. The tamarind-tree refreshes and embellishes the country by its agreeable shade and elegant form. The balm-tree is peculiar to Arabia, which is also the native country of the coffee-tree, though, according to the Arabians, it comes originally from Abyssinia. The balm-tree has not a beautiful appearance, and its qualities are not appreciated in the southern province of Yemen, where its wood is burnt for a perfume. In the Hedjaz the inhabitants collect the balsam and bring it to Mecca: it is thence exported to Turkey, where it is in high estimation. The tree from which incense distils is found in part of Hadramaut, along the shores of the Indian Ocean. Arabia has been in all ages celebrated for sweet-scented shrubs and trees; and Burckhardt mentions, that one morning at sunrise, when he was on his road from Tayf to Mecca, every tree and shrub exhaled a delicious fragrance. There are various species of the sensitive plant, of which the splendid flowers, of a beautiful red, are formed into crowns for festive occasions. The sugar-cane and the indigo-shrub are found in different provinces; and the shrub from which senna is produced is cultivated in all that part of the country which lies opposite to Upper Egypt. The Arabians cultivate garden vegetables, such as lettuce, carrots, radishes, water-cresses, and a great variety of gourds, cucumbers, pumpkins, and melons. The melon is in such variety and abundance that, for a part of the year, it constitutes an article of food. Many plants and herbs which have been brought from India are now naturalized in the country; and there is abundance of indigenous plants, noted for the beauty of their flowers and their fragrant smell. The gardens at Tayf, among the mountains, 72 miles east of Mecca, are renowned for roses of such exquisite beauty and fragrance, that they are sent to all parts of the country. The soil of the desert, though it is sandy, yet yields a variety of herbs, which constitute the food of cattle; and every district has a peculiar plant, which will grow in no other part. Those herbs grow to the height of three, and some of them of six feet; and when they are withered by the sun they are eagerly devoured by the camel.[1]

The wild animals of Arabia, which are principally found in the mountains, are the panther, sometimes mistaken for the tiger, the ounce, the hyena, the wolf, the fox, a species of wild dog of a black colour, common in many countries in the East, the wild cat, the jackal, the wild ox, and monkeys in great numbers. In the sandy tracts is found that curiously constructed animal the jerboa. The wild boars are very numerous, but not in the heart of the desert. The Arabs who live at Tadmor in northern Arabia are famous for their dexterity in killing them with the lance. The beautiful and timid gazelle is found all over the Arabian desert. On the eastern frontiers of Syria there are several places allotted for the hunting of these animals, which are taken by hundreds. There are several sorts of lizards, and the land-tortoise is common, being brought by the peasants in cart-loads to the markets of many towns in the East. The domestic animals are the horse, the ass, the camel, and the ox.

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Horses.

The Arabian horse has been justly renowned in all ages of the world for all the finest qualities, namely, swiftness, patience of fatigue, spirit, and docility of temper; and it is from the Arabian breed that the European horses derive all their most valuable properties. The best horses are found in the greatest numbers in the luxuriant pastures of Mesopotamia, the banks of the Euphrates, and in the Syrian plains. In Nedjed the horses are also of a very fine quality, though they are not so numerous as in these countries; and they are still more scarce in the southern provinces of Yemen, Oman, and Hadramaut, on the shores of the Indian Ocean, owing to the great heat of the climate; nor are the mountainous regions of the Hedjaz favourable to the rearing of this fine animal. There are not, according to Burckhardt, more than 6000 horses in the whole western country of Arabia, from the northern point of Akaba on the Red Sea to the southern coasts, comprising the great chain of mountains and the western plains. The provinces of Yemen, Hadramaut, and Oman, are also supplied with horses from the pastures of Nedjed.

In the wars and inroads of the desert, the Arab soldier, whether he is pursuing, or flying for his life over the naked plain, wholly relies on the quality of his horse. On this account they spare no pains in rearing their horses, and in preserving the purity of the breed. The birth of every noble foal is ascertained by the presence of eye-witnesses, and a written certificate is made out of its distinctive marks, with the names of its sire and dam, which is wrapt in a small piece of leather covered with wax-cloth, and is hung round the animal's neck as the standard and evidence of its value. The genealogical table never ascends to the grand-dam, because every Arab knows by tradition the purity of the whole breed; and there are many horses and mares of which the noble descent is of such notoriety throughout the tribes, that no written evidence of the fact is required. The Arabs reckon five noble breeds of horses, whose lineal descent they assert to be from the five favourite mares of the prophet. But as all the collateral branches claim the same illustrious ancestry, there is an infinite variety of noble breeds in the desert; and every mare which is particularly handsome, and belonging to any of the five chief races, may give rise to a new breed, the descendants of which bear her original name. Those pastoral tribes, when a foal is born, receive it in their arms, and so cherish it for several hours, stretching its tender limbs, and caressing it as if it were a child; and when it is placed on the ground, they watch its feeble steps, prognosticating its future excellencies or defects. The colt is mounted after its second year, after which it is fed upon barley, which is the usual provender throughout Arabia, though in Nedjed the horses are regularly fed on dates; and the wealthy inhabitants give them flesh, raw as well as boiled, and all the fragments of their own meals. In other respects they are hardily treated. They remain in the open air during the whole year, with the saddle constantly on their backs, and are not even taken under the shelter of the

[1] Burckhardt's *Arabia*, vol. ii. Appendix.

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tent in the rainy season, or during the heat of the mid-day sun; yet with all this treatment they are seldom ill. The Arabs never clean or rub their horses; but they are careful to walk them about gently on their return from a ride. They prefer mares for riding, on account of their more patient endurance of fatigue, hunger, and thirst, than horses, and because they are gentler and less vicious, and never neigh when they are lying in ambush to surprise passengers. According to Burckhardt, the finest race of Arabian blood horses may be found in Syria; and of all the Syrian districts the breed in the Hauran is the best. But all the horses of the noble breed are not equally distinguished. Among these there are only a few, perhaps not above five or six in a whole tribe, of the first-rate class in respect to size, bone, beauty, and action. In the whole extent of the Syrian deserts there are not, according to the estimate of this traveller, more than 200, worth, even in the desert itself, about L.150 or L.200 each; and of these very few, if any, have ever found their way to Europe, although many horses of second and third-rate quality from Syria, Barbary, and Egypt, have been imported into England, and have passed for the pure Arabian breed. The price of horses in Syria is from L.10 to L.120. An Arab mare cannot be obtained under L.60: a celebrated mare will often bring from L.200 to L.500. A mare is frequently the joint stock of two, three, four, or any greater number of proprietors; and when she has foaled, the colt is sold, and the price is divided among the proprietors. Burckhardt mentions a scheik who had a Nedjed mare, for the half of whose belly, according to the phraseology of the Arab market, he paid L.400. D'Arvieux mentions an emir who "had a mare that he would not part with for 5000 crowns, because she had travelled three days and three nights without drawing bit, and by that means got him clear off from those that pursued him." A similar anecdote is told of a troop of Druses, who, having attacked an Arab encampment, were assailed by a superior force, and all killed except one man, who fled, and was pursued by some of the best mounted Bedouins. "But his mare, although fatigued, continued her speed for several hours, and could not be overtaken. Before the pursuers gave up the chase, they cried out to the fugitive, promising him quarter and safe-conduct, and begging him that he would allow them to kiss the forehead of his excellent mare. Upon his refusal they desisted from pursuing, and, blessing the generous creature, they exclaimed, addressing her owner, "Go and wash the feet of your mare, and drink up the water;" a phrase by which the Bedouins express their sense of the invaluable services rendered by those fine animals.[1] The Arabs treat the mares which they keep for riding with invariable tenderness. They never beat them, but make much of them, reason with them, talk with them, and take all imaginable care of them. They never spur them, except in cases of peculiar urgency, when the generous animal flies over the plains with so rapid a motion that the rider is apt to be stunned. Many curious instances are given by travellers of the care and affection with which the Arabs treat their horses. An affecting anecdote is related of an Arab, who having sold the half of a mare renowned for beauty and other fine qualities, for 1200 crowns, made frequent journeys to inquire after her welfare. "I have many a time," says D'Arvieux, "had the pleasure to see him cry with tenderness, whilst he was kissing and caressing her. He would embrace her, would wipe her eyes with his handkerchief, would rub her with his shirt-sleeves, would give her a thousand blessings during whole hours that he would be talking with her. 'My eyes,' would he say to her, 'my soul, my heart, must I be so unfortunate as to have thee sold to so many masters, and not to keep thee myself? I am poor, my Antelope; I have brought thee up like a child; I never beat nor chid thee. God preserve thee, my dearest; thou art pretty, thou art sweet, thou art lovely; God defend thee from the looks of the envious!' He then embraced her, kissed her eyes, and went backwards, bidding her the most tender adieus. Another Arab, who had sold his mare and put the money in the bag, looked wistfully on the animal, and began to weep. 'Shall it be possible,' said he, 'that, after having bred thee up in my house with so much care, and had so much service from thee, I should be delivering thee up in slavery to the Franks for thy reward!' on which he threw down the money on the table, embraced and kissed the mare, and took her back to his tent."[2]

The camel is an invaluable animal in Arabia, being peculiarly qualified, by its power of enduring thirst and fatigue, for traversing its burning plains. The camels of the Arabian and Syrian deserts are of a smaller make than those of Anatolia or Kurdistan and other northern countries, and they have only one hump. They are used either for the purposes of riding, or for carrying heavy burdens. The smaller and more active camels, or dromedaries as they are termed, or in Arabia *deloul*, which are used for riding, are the same race as the heavier camels, which are employed in carrying burdens, being merely distinguished as a hunter is from a coach-horse. The common load of an Arabian camel is from 400 to 500 pounds on a short journey, and from 300 to 400 pounds when the distance is greater. The Egyptian camel, which is equal in strength to the Anatolian, will carry a load of three bales of coffee, equal to 1500 pounds, from Cairo to the water-side, a distance of three miles. The dromedary, or the riding camel, is used in travelling, though in speed it is far surpassed by the horse. Incredible stories are told of the wonderful expeditions performed by these animals. Burckhardt was assured by a Bedouin that his grandfather made a journey on a camel of 250 miles in one day; and he himself mentions that, on a wager, a camel was engaged to go in one day, between sunrise and sunset, a space of 125 miles; and actually travelled in 11 hours 115 miles, when its strength failed. The rate of speed at which a camel goes, even on a gallop, which is not his natural pace, and cannot be maintained above half an hour, is never more than 16 or 18 miles in the hour. In trotting, 12 miles an hour is the utmost limit of his speed, which may be continued for several hours. But a camel will carry his riders without interruption for several days and nights, in an easy and gentle amble, the favourite pace, at the rate of about 5 or $5\frac{1}{2}$ miles in the hour, and will travel for five or six days 10 or 11 hours each day. A sort of palanquin is fixed on the backs of these camels for women, in which they are concealed from the public eye, and may stretch themselves at full length. The capacity of bearing thirst varies considerably in the different races. The Arabian camel must be watered on the evening of every fourth day. Some animals, though they may go five days without drinking, cannot be safely exposed to such a trial. The caravan routes are never at a greater distance than three or three and a half days' journey from water; but the caravans from Africa to Egypt travel, during the heat of summer, through deserts in which water is wanting, for nine or ten days; and though many camels perish, the greater number come safely to Egypt. The Turcomans

[1] Burckhardt's *Notes on the Bedouins and Wahabys.*

[2] D'Arvieux, chap. xi.

and Kurds purchase every year from 8000 to 10,000 camels in the Syrian deserts, of which the greater part are brought originally from Nedjed. The price of a camel varies almost in every place. In Hedjaz a common riding camel may be bought for 50 or 60 dollars, and for some of the first quality 200 and even 300 dollars are sometimes paid.

The wild ass is found in great numbers in the country adjoining the district of Djof, to the west of Djebel Shammar, between Tobeck, Sauan, and Hedrush, and to the south of those places. It is hunted by the Arab tribes, who eat its flesh, and sell its skin and hoofs to the pedlars of Damascus and to the people of Hauran. Out of the hoofs rings are made, which are worn by the peasants as a charm against rheumatism. The domesticated ass in Arabia, as in all the other countries of the East, is a strong, active, and spirited creature, the rival of the horse in utility, if not in beauty. It retains all the strength, swiftness, and fire of the wild animal.[1] Arabia is not famous for horned cattle. The cow is used, however, in many places, for drawing water from the wells, and other purposes. It is small, and of a stout, bony make, with short stumps of horns, and a hump on the back over the shoulder, like the cows on the Nile and in Nubia.[2] The northern tribes of Arabia, namely, the Aenezes, and the Ahl el Shemal, possess abundance of goats and sheep. The goats are mostly black, with long ears. The sheep have not the fat tails of those that are found in some countries; their ears are rather longer than those of the common English breed. The Arabs use in their families the milk of their flocks. They also make great quantities of butter, part of which they sell to the peasants and town's people.

Arabia produces a considerable variety of birds. In the fertile provinces tame fowls abound, and all sorts of poultry. The pintado inhabits the woods in such numbers that children kill them with stones and collect them to be sold in the towns. In the forests of Yemen pheasants abound; also the wood-pigeon, and other varieties of the same species. In the plains is found the gray partridge, the common lark, the wild goose, and a species of white crane having the under part of the belly of a beautiful red. Eagles, falcons, sparrow-hawks, and the Egyptian vulture, are the Arabian birds of prey. The last clears the country of all carrion, and also of field mice, which multiply prodigiously in some provinces. There is another bird of prey, of the thrush species, which is equally useful in pursuing and destroying the swarms of locusts with which the country is infested. There are various birds which are little known, and which are supposed to be birds of passage from India, distinguished by peculiar brilliancy of plumage. There is one which has two large and beautiful feathers, with which the Arabians adorn their caps; and another which, for its rare beauty, is sold for a high price. A beautiful lapwing is common on the shores of the Persian Gulf. The sandy tracts of the desert abound in ostriches: these are hunted by the Arabs for their feathers, which form a valuable article of trade. The ostrich inhabits both the great southern and northern deserts. They abound in the plain extending from Hauran towards the central provinces of Djebel Shammar and Nedjed. Some are seen in Hauran, and a few are taken almost every year within two days' journey of Damascus. They generally breed in the winter, and the Arabs discovering the nest, scare away the birds, when they resort to the following contrivance for destroying them:—A hole is dug in the ground near the eggs, into which the Arab places a loaded gun, with a long burning match fastened to the lock. The ostriches resume their place generally both at once on the eggs: in due time the gun is discharged, and next morning the Arabs find one or both of the ostriches laid dead beside the eggs. The feathers are sold at from L.2. 6s. to L.2. 10s. per pound, and the finest at from one to two shillings each. In places where there is water, plovers and storks abound; and sea-fowls, feeding on fish, are numerous on the coasts of the Red Sea, which is deep, and copiously stored with their food. Here, and on the isles along the shore, the pelican is to be found.

The heat of the climate favours the breed of serpents, some of which only are dangerous, while others are perfectly harmless. The only one that is truly formidable is a small slender creature, with black and white spots, whose bite is followed by instant death, and an extraordinary swelling of the body from the malignity of the poison. Of the insects in Arabia, the most remarkable as well as the most destructive is the locust, which flies in swarms that darken the air, and with a frightful and stunning noise, such as is made by a water-fall. The fields are entirely despoiled of their verdure by these insects. The pulse and the date trees are also greatly injured; but the corn, when it is nearly ripe, resists, by its hardness, their attacks. Locusts are found in all parts of the Arabian deserts. They come invariably from the East,—from the waters of the Persian Gulf, according to the notions of the rude Arabs. In the central province of Nedjed they not only destroy the produce of the fields, but penetrate by thousands into private dwellings, where they devour whatever they can find, even to the leather of the water-vessels. In the peninsula of Sinai the inhabitants are driven to despair by swarms of locusts, which consume the fruits of the earth. All the Arab tribes, as well as the inhabitants of towns, are accustomed to eat this insect; and at Medina and Tayf there are shops in which they are sold by measure. After being salted, whole sacks are filled with them. The destructive insect the white ant, which preys upon victuals, clothes, furniture, and the leaves of trees, is common. There is another ant, whose bite is like that of the scorpion, although it is not dangerous. The scolopendra affects those whom it attacks with burning pains. It fixes its feet so firmly in the flesh that it cannot be got out but by burning the part with a hot iron. Other insects destroy reeds and stalks of corn, and make their way into houses. There are many species of crabs, some of them peculiar to the Red Sea, which are excellent, and, but for the peculiar aversion of the Mussulmans to shell-fish, would afford a wholesome subsistence. At Suez they form almost the sole food of the Copts.

Arabia has never been noted for its minerals. It was supposed by the ancients, who had the most exaggerated ideas of its wealth and produce, to abound in precious stones, as well as gold and silver. Except it be the onyx, which is found in Yemen, and the cornelian, it produces no other stones of value. It does not contain anywhere mines of gold or silver, nor is this precious ore ever washed down by the mountain streams. There are mines of fossil salt among the mountains, which were formerly worked, but are now neglected; and the iron of Yemen is found to be of a coarse quality and brittle. In Oman are very rich lead mines, the produce of which is largely exported from the harbour of Mascat, in the Persian Gulf.

Burckhardt, whose posthumous work[3] contains the most ample and satisfactory details of Arabian manners, gives a

[1] Niebuhr, vol. ii. chap. iii. Burckhardt's *Notes on the Bedouins and Wahabys.*
[2] Burckhardt's *Travels in Arabia*, p. 127.
[3] *Notes on the Bedouins and Wahabys.*

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particular classification of the Bedouin tribes. Those who inhabit northern Arabia he distinguishes into two classes; namely, the Aenezes, who migrate with the spring and summer to the fertile parts of Syria, and return with the winter to the desert; and others, who remain the whole year in the vicinity of the cultivated tracts. The Aenezes, reckoning their brethren in Nedjed, form one of the most powerful associations of shepherds in the Arabian deserts. They levy contributions on the Syrian villages, as well as on the pilgrim caravan in its passage from the desert to Mecca; and their numbers are estimated at from 300,000 to 350,000, and their military force at 10,000 horsemen, and from 90,000 to 100,000 camel-riders.

There are numerous other tribes in northern Arabia, scattered along the frontiers of Syria and the banks of the Euphrates. They are not so migratory in their habits as the Aenezes, with whom several of them carry on the most deadly strife, while others pay a yearly tribute to all the chief Aencze tribes, and in some cases to the pacha of Damascus. Many of them cultivate the land though they dwell in tents; and those on the borders of Syria carry their produce of milk, butter, and cheese to the market of Aleppo. There are other tribes that range over the country to the south, over the mountains that run in a direction parallel to the Red Sea as far as Medina and Mecca, or in the interior plains and mountains of Djebel Shammar, Kasym, and Nedjed. Some of those tribes, as the Beni Shammar, can muster from 3000 to 4000 men, armed with matchlocks; others, such as Meteyr, who occupy the fruitful pastures of Nedjed, 1200 horse, and from 6000 to 8000 matchlocks. The country from Kasym towards Medina and Mecca, and the coast southward from Yembo to Djidda and Leith, for about 250 miles, is inhabited by the Beni Harb, which, next to the Aenezes, is the most powerful tribe in Arabia. They can muster from 30,000 to 40,000 men, armed with matchlocks. The Harbs are partly settlers and partly Bedouins. They may be styled the masters of the Hedjaz, and were the last tribe in those countries that yielded to the Wahaby arms. They take a yearly tribute from the Egyptian and Syrian caravans; and they extend their predatory inroads against the encampments of the Aenezes to the vicinity of Damascus. On the sea coast, where the territory is poor, they derive a subsistence from fishing; and many of them are sailors, and act as pilots between Yembo and Djidda. But these tribes, from their intercourse with the inhabitants of towns, and their maritime habits, are regarded with disdain by the genuine Arabs. To the east of Mecca and Tayf, in the fruitful pastures of the interior, resides the brave and powerful tribe of Ateybe, the inveterate enemies of the Beni Harb, who can muster a force of 10,000 matchlocks. In the neighbourhood of Mecca are many well-known tribes, now reduced to about 250 or 300 matchlocks. The tribe of Korcish, so famous in the Arabian annals, who encamp near Mount Arafat, now amount only to 300 matchlock-men. The tribe of Adouan, which 40 years ago mustered about 1000 matchlocks, and were celebrated all over Arabia for their valour and hospitality, are now reduced to 100 families. It is to this tribe that the reigning sherifs of Mecca send their children to be educated. In the mountainous region between Mecca and Tayf reside the warlike tribes of the Hodheyl, mustering 1000 matchlocks, famed as excellent marksmen, brave soldiers, and daring high-way robbers; the Toweyrek, who muster 500 matchlocks, and have the character of dexterous thieves; and the Thekyf, who possess the garden country around Tayf, and the other equally fertile valleys on the eastern declivity of th great Hedjaz chain of mountains. The wealth of thes mountain tribes consists in flocks of sheep and goat They suffered severely, especially the Hodheyl, in thei obstinate but unavailing resistance to the Wahaby From Tayf southward, along the eastern face of the grea chain of mountains to Sana, are several ancient an powerful tribes, renowned in Arabian history. Som are partly cultivators and partly Bedouins. The Ben Kahtan and the Beni Sad are famous from the mos remote antiquity. The former is exclusively pastora abounding in camels above any other tribe of the deser Some of these southern tribes can muster from 500 t 1500 matchlocks. They are brave and warlike, and the extend from the mountains over the eastern and wester plains. The tribe of Asyr can assemble 15,000 men armed with matchlocks. Of the various tribes scatter ed over the mountains of Yemen and Hadramaut, an the countries that are washed by the Persian Gulf, w have no detailed or accurate accounts. The tribes i the mountains are, however, in general employed in agri culture; many of them live in tents, and descend i spring into the neighbouring plains for pasture to thei flocks. The cultivators dispose of their produce, whic is abundant, in the towns on the coast.

Arabia has been celebrated from time immemorial a the seat of independence and of pastoral simplicity, an it is perhaps the only country in the world which, unti it was lately overrun by the troops of Mohammed Ali, wa never profaned by foreign conquest. Mountains and de serts, as is well observed by Sir John Malcolm,[1] have bee in all ages the sanctuaries of the brave and the free; an thither the hardy Arabs, when pressed by powerful armies have always fled to enjoy freedom and independence. O the sea coasts and in the towns the Arab character ha been corrupted by commerce and a free intercourse wit foreigners; but in those secure recesses the ancien manners of the country are still to be found. The ge nuine inhabitants of the desert unite the character o shepherds and soldiers. They live in tents, and the subsist by maintaining flocks of sheep and camels, an also cows and horses. The larger tribes are chiefly em ployed in rearing camels, which they either sell to thei neighbours, or employ in the carriage of goods or i military expeditions. The petty tribes maintain flocks o sheep. They disdain the cultivation of the ground, as a employment degrading to a pure Arab, and which they ac cordingly leave to the inferior race of peasantry and slaves These Bedouins live the usual vagrant life of shepherds emigrating from one place to another with the change o the seasons, in quest of pasturage, and transporting thei dwellings along with them; so that a village arises ofte in a situation where, an hour before, not a hut was to b seen. The genuine Arabs, who live constantly in the ope air, acquire a remarkable acuteness in all their senses Their powers of vision and of hearing improve by constan exercise; and on the vast plains of the desert objects in visible to a less practised eye are at once seen by them Their sense of smelling is extremely acute; and their dis like to a town life is occasioned by the nauseous exhala tions which are produced among such a dense collection o people. The Arabs possess the same faculty of nicel distinguishing on the sand the footsteps of men and beast which the American Indians distinguish on the grass. T such perfection have they arrived in this art, that a Arab will at once recognise the footstep of any one o his own or of some neighbouring tribe; he will know

[1] *History of Persia.*

whether the person carried a load; whether he passed the same day, or a day or two before; whether, from a certain irregularity in the steps, he was fatigued, had come from a distance, and how far he has any chance of overtaking him. He knows at once the footsteps of his own camel—whether it was heavily loaded, or mounted only by one or more persons. A keen Arab guide has his eye constantly on the footsteps which he sees; and Burckhardt mentions that he has seen a man discover and trace the footsteps of his camel amid thousands of other footsteps crossing the road in every direction, and, by an inspection of the footsteps, tell the name of every person who had passed there in the course of the morning. Many secret robberies are brought to light by this power of nice observation. Instances have been known of stolen camels found after a journey of six days; and so long as the traces of men or camels can be seen on the sand by the practised Arab's discriminating eye, robberies are almost sure of detection. So thoroughly are the Bedouins inured to fatigue and the want of water, that they will wander about five days without tasting it, and will at last discover a pit of water by examining the soil and plants in the environs. They ride on horses and camels, and are continually armed with a lance, a sabre, and sometimes a matchlock or a pistol. Some of them wear coats of mail. All those wandering shepherds are addicted to violence, and to the fierce habits of a military life. They are either engaged in open war about their wells or pasture grounds, or in plundering excursions or secret robberies, which they do not consider to be in any degree criminal; and no more flattering title can be conferred on an Arabian youth than that of robber. The defenceless traveller, whom they descry from afar on the level plain, is marked out for their prey. He is seized, stript of every thing, and left naked in the desert. If he resists, and more especially if he sheds the blood of a Bedouin, they take his life. But the Arab plunders indiscriminately strangers and neighbours, enemies and friends, provided they are not actually in his own tent, where it is not reckoned honourable to rob, though acts of this nature daily occur, without drawing after them any lasting disgrace. Associations are frequently formed for the plunder of caravans, or of the cultivators who dwell in villages, whose cattle they carry off, and sometimes, though very rarely, their young women. In those cases they proceed with a considerable force. Their chief object, however, being still plunder, the great point of Arab tactics is to surprise the enemy's encampment, and to carry off the cattle and the camels. They seldom engage in any sanguinary conflicts; for though the Arab, in facing the enemies of his country, behaves like a brave soldier, he is a mere poltroon in his plundering expeditions; and the caravan travellers and peasants frequently put to flight three times their own number of those wandering robbers. In undertaking an expedition for plunder at the distance of ten or twenty days' journey, every horseman who is of the party chooses a companion, who is mounted on a young and strong camel, and who carries a provision of food and water. He mounts behind this companion, that his mare may be fresh and vigorous at the moment of attack. In approaching the enemy's camp, the horsemen advance, leaving their followers and the camels behind, with instructions to await their arrival. The horsemen are sometimes all destroyed in the expedition; and they are at other times separated from their followers who carry the provisions, and either inevitably perish in the barren plain, or submit to be stript and plundered by their enemies. In the most inveterate wars of the Arabs the women are invariably respected; and neither men, women, nor slaves, are taken prisoners. Night attacks are generally avoided, lest during the confusion the women's apartments should be entered, which would produce a desperate resistance, and probably in the end a general massacre—an extremity which the Arabs always try to avoid. The attack of a camp seldom occasions any great loss of lives, because no opposition is offered to superior numbers; and a Bedouin, except in avenging blood, never puts to death an unresisting foe. In flying from his enemy, an Arab may save his life by throwing himself from his horse and asking for mercy; but he saves it at the expense of his honour, and loses his horse and all his clothes, while his enemy will ever after triumph over him. The more spirited of the Arabs defy their adversary, while he pursues them, calling out repeatedly, "Howel, howel," get down, get down, and who, when his call is not obeyed, wounds or kills his enemy with a thrust of his lance. Among some of the Arab tribes it is the practice to steal unobserved on the enemy's encampment during the night, and knocking down the principal tent-poles, to drive off the cattle amid the confusion.

But the Arabs often undertake merely thieving expeditions, in which they steal from friend and foe. The mode in which these are conducted affords some curious details of manners. In such enterprises ten or twelve persons usually engage, and clothe themselves in rags, to make their ransom easier if they should be taken. When they approach the camp which they intend to rob, three of the most daring advance about midnight, when its inmates, who seldom plant sentinels, are buried in sleep. One of the thieves now endeavours to excite the attention of the watch-dogs. When they attack him he flies, and draws them off to a great distance, by which the camp is left unprotected. Another, called *el haramy*, or the robber, advancing towards the camels that are upon their knees before the tent, cuts the strings that confine their legs, when they rise and walk, as all unloaded camels do, without the least noise. One of the she camels being then led out of the camp, all the others follow. The third actor in the robbery watches at the tent door with a long and heavy bludgeon, with which he knocks down any of the inmates who may come forth. It often happens that as many as fifty camels are stolen in this manner, and driven away by forced marches during the night to a safe distance. In many cases, however, the robbers are surrounded and seized; and the mode of treating these prisoners is extremely curious, and is a proof how powerfully these fierce barbarians are influenced by prejudice and immemorial usage. It is an established custom among the Arabs, that if any person who is in actual danger from another can touch a third person, or any inanimate thing which the other has in his hands, or if he can touch him by spitting or throwing a stone at him, and at the same time exclaims "I am thy protected," he is bound to grant him the protection which he requires. This law, however absurd and capricious, seems naturally to arise out of scenes of violence, the evils of which it is calculated to soften. A prisoner detected in the act of plundering anxiously looks about for a protector, while the inmates of the tent are equally desirous to deprive him of this privilege. The person who first seizes him demands on what business he is come, accompanying his question by blows on the head. "I came to rob—God has overthrown me," is the common answer. The captor (the *rabat*), binding the hands and feet of his prisoner, and calling in the people of his tribe, addresses him, saying, "renounce;" and the robber, fearing a continuation of the blows, answers, "I renounce," namely, the benefit of any protector. But this renunciation being only valid for a day, the prisoner is secured in a hole dug

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in the ground, about two feet deep, and large enough to contain him. Here he is laid, his feet chained to the earth, his hands tied, and his twisted hair fastened to two stakes on both sides of his head. Some tent-poles are then laid across this temporary grave, and corn-sacks and other heavy articles heaped upon them; a small opening being only left, through which he may breathe. Thus buried alive, the prisoner does not despair; and customs that are established among the Arabs sometimes favour his escape. If from his hole he can contrive to spit into the face of a man or a child, or if he receive a morsel of bread from a child, he claims the privilege of being protected. His mother or his sister sometimes contrive to enter the camp in which he is confined, in the disguise of a beggar. Approaching during the night the hole where he lies confined, and throwing a thread of worsted over his face, they guide it to his mouth, or fasten it to his foot; and by this token he knows that help is at hand. The woman winding off the thread, retires to some neighbouring tent, and awakening the owner, and placing the thread on his breast, addresses him in these words: "Look on me by the love thou bearest to God and thy own self—this is under thy protection." The Arab comprehends at once the object of this nocturnal visit, rises, winds up the thread, and being thus guided to the tent of the prisoner, awakens the captor, and showing the thread still held by the prisoner, claims him as his "protected." The right of freedom is at once allowed; the thongs which tied his hair are cut, his fetters are taken off, and he is entertained by the captor as his guest with all the honours of Arab hospitality. A prisoner sometimes remains for six months under this rigorous custody, always concealing his real name, and giving himself out for a poor beggar. He is generally discovered, however, when he must pay as a ransom all his property in horses, camels, sheep, tents, provisions, and baggage. In many cases a sum is agreed upon for his ransom, and he goes to his tribe to collect it, or find a surety for the payment. If he cannot collect the necessary sum among his friends, he is bound to go back to his prison; and he seldom fails either to pay or to return. A father considers his son to have acquired high honour in being detained as a robber, and he willingly redeems him with his whole property, which he hopes to recover in some future expedition.

Nobility of Arabia.

The Arabs are remarkable above all the nations of the earth for the spirit of clanship and for pride of family. The scheiks, or the rulers and nobles who govern Arabia, glory in their ancestry, which they can trace with undoubted accuracy to a long line of princes. Nobility of birth, which cannot be communicated by the smile of kings, is the true distinction of the Arabian aristocracy; and no scheik would exchange his title for any distinction depending on court favour. Those genuine nobles, who dwell in tents, look with contempt on the dwellers in cities, as a race debased by foreign alliances, which they hold in such contempt, that a scheik, if he were forced from poverty to marry his daughter to a citizen, would consider himself disgraced by the match. Besides the scheiks there are the sherifs or sejids, or, in the Mahometan countries to the north of Arabia, the emirs. These are the descendants of Mahomet, who hold the first rank among the great families of Arabia, and who receive the double honour that is due to splendid descent and superior sanctity. The title of sherifs distinguishes them from the scheiks, the common order of Arabian nobility. They are multiplied over all Mahometan countries. Whole villages are peopled with them, and they are frequently found in the lowest state of misery. The sherifs of the Hedjaz, who were once numerous, but are now reduced to a few families in Mecca, have never contaminated their pure blood by strange alliances; and they are esteemed above all the other descendants of the prophet. The presence of a sherif commands universal respect. In a fray no arm would violate his person; his property requires no protection; the sanctity of his character supplies the place of bolts and bars, and scares away the boldest thieves.

From these sherifs are chosen the rulers of Mecca and its adjacent territories, extending for about 250 miles along the coast, from Yembo on the north, to Haly or Gonfode on the south. Before the country was conquered by the Wahabys, and again by the Turkish troops under Mohammed Ali, they possessed the power of sovereigns within their dominions; and though they held their authority ostensibly under the grand signior, being installed in their office by an investiture of a pelisse from Constantinople, thus formally acknowledging themselves his servants, and praying for him in the great mosque, they were in reality elected by the powerful sherif families resident at Mecca, and they ruled according to the constitutional maxims of the desert, merely as Bedouin chiefs. The Arab tribes looked upon them as one of their own scheiks, the head of the family or clan; and they followed them in war under their own immediate chiefs, without receiving pay. In this manner Ghaleb, the last sherif, was accompanied in his wars against the Wahabys by 6000 or 8000 Bedouin Arabs. A system of well-regulated freedom was not to be expected from the rude policy of wandering shepherds, and the Arab chiefs accordingly own no restraint on their authority. But the rigour of despotic sway is softened by the influence of manners; and the independent princes of Mecca, in the pride of sovereignty, still acknowledge the ties which bind them to the simple Bedouins of the desert. The sherif descendants of Mahomet who reside at Mecca retain a singular practice of sending every male child, eight days after it is born, to the tents of some wandering tribe. Here he remains till his 8th or 10th year, when he is able to mount a steed, and sometimes till his 13th or 15th year. During all this period he only pays one short visit to his father's house, in his sixth month, when his foster-mother returns with him to her tribe. The boy is trained by those shepherds in all warlike exercises: he shares in their hardships and perils, is familiarized with their manners, and acquires their pure language, and a lasting influence over them; while his affections, awakened at an age when the mind is peculiarly susceptible, still attach him to the scenes of the desert and the companions of his youth. The tent of a Bedouin shepherd is in this manner the constitutional school of an Arabian prince, in which he imbibes the maxims by which he afterwards rules the state. Some of the sherif boys become so fond of their foster-parents that they can scarcely be reconciled to their fathers' house; and they have been sometimes known, after being settled at home, to escape to their friends in the desert. "The Bedouins," says Burckhardt, "in whose tent a sherif had been educated, were ever after treated by him with the same respect as his own parents or brethren: he called them respectively father, mother, brother. Whenever they came to Mecca they lodged at his house, and never left it without receiving presents. He considered himself during his life as belonging to the encampment in which he had passed his early years; he termed its inhabitants 'our people,' or 'our family,' took the kindest interest in their various fortunes; and, when at leisure, often paid them a visit during the spring months, and sometimes accompanied them in their wanderings and their wars." Sherif Ghaleb, whose reign was terminated by Mohammed Ali in 1815, was remarkably attentive to

his Bedouin friends. They alighted at his house in Mecca just as they alight at the tent of a scheik in any Arab encampment of the desert; and when they departed, their sacks were filled with provisions for the road. On their arrival he used to rise from his seat and embrace them, though they were in the same mean attire as the other inhabitants of the desert. Many of the sherifs are also married to Bedouin girls.

A sherif was generally succeeded by his relative, whether son, brother, or cousin, who had the strongest party, or the public voice in his favour; but it was seldom that an election took place without a violent contest, which frequently ended in bloodshed and civil broils. These, however, were carried on according to the laws of the desert, and they were seldom of long duration. The happiness of the people under these sherifs always depends on the personal character of the ruler. There are no tribunals to which the oppressed can fly for redress, and a sherif may harass his subjects to any extent by his extortions. He may imprison the refractory, and even put them to death, without endangering his authority. Such is the despotic character of all eastern governments.

In the Ottoman provinces the dignity of sherif is less respected, though even in Turkey they enjoy some substantial privileges. In the towns where they reside, the sherif or emir is subject, not to the pacha, but to a member of his own family, who is denominated nakib or general of the sherifs. Besides the scheiks and sherifs there is another branch of nobility at Mecca, who have an hereditary right to certain employments at the mosque, and who have a strong inducement to preserve an exact record of their genealogy. These are certain families descended from the tribe of Koreish, who hold the office of keeper of the keys of Kaaba, which is the most important office about the mosque, and was often an object of contention among the ancient Arabian tribes; and others who are muftis, or are employed in other capacities, and who, to preserve their title to these envied privileges, can show a faithful record of their ancestors for ten centuries back. There were formerly 12 other illustrious families of the tribe of Koreish, who are now reduced to three.[1]

Arabia is divided into numerous petty states, governed by independent chiefs or scheiks, who are, strictly speaking, the heads of families; and the paternal government thus supplies the model of the Arabian institutions. The father is in all cases the natural ruler of his own family; and though the tie be necessarily weakened as families multiply, yet the relations of kindred and of blood are still acknowledged, and all the descendants unite in paying respect and reverence to their common head. An assemblage of families constitutes a tribe; and all the scheiks of the same tribe acknowledge a common chief, who is called the *scheech es scheuch*, or the scheik of scheiks, or the grand scheik or prince, who rules over the whole. The dignity of the grand scheik is hereditary in the family; but it is so far elective that he is chosen by the inferior scheiks, from the whole members of the reigning family, without regard to seniority or lineal succession: his only distinction is his qualification for the office. The right of election, as well as other privileges which belong to the inferior scheiks, obliges the grand scheik to treat them rather as associates than as subjects, and in some measure to share with them his sovereign authority. If they are aggrieved by him, they depose him, or emigrate with their cattle to other tribes; and in this manner many powerful tribes have been weakened, while the number and the power of others have been augmented.

The scheik has in fact no acknowledged or formal authority over his tribe. His commands would be treated with contempt, and his advice only is received with the deference due to experience and talent. "The prerogative of the scheik," says Burckhardt, "consists in leading his tribe against an enemy, in conducting negotiations for peace or war, in fixing the spot for encampments, in entertaining strangers of note; and even these privileges are much limited. The scheik cannot declare war or conclude peace without consulting the chief men of his tribe. If he wish to break up the camp, he must previously ask the opinions of his people concerning the security of the roads, and the sufficiency of pasture and water in the districts to which he directs his view. Thus he strikes his tent and loads his camels without desiring any one to do so; but when they know that the scheik is setting out, his Arabs hasten to join him." The Arabs are jealous of authority, and their freedom borders on anarchy. The Bedouin acknowledges no master but the Lord of the universe; and the most powerful chief, by inflicting punishment on the poorest man of his tribe, is exposed to the mortal vengeance of himself or his relations. A scheik, in place of deriving a yearly income from his tribe, is bound to show liberality, especially in his treatment of strangers; to maintain the poor, and to divide among his friends whatever presents he may receive. The only revenue possessed by the northern chiefs is the tribute which they extort from the Syrian villages, and from the pilgrim caravan to Mecca. Among the numerous principalities in the south of Arabia, the scheik or imam imposes a land tax and a poll tax, also port and transit duties on all articles of merchandise, some of which, as on coffee, are very heavy. These duties on goods are not, as they have been sometimes considered, a mere ransom from pillage, but a tax and an acknowledgement of the paramount authority of the prince. Among so many petty sovereignties wars frequently arise, from the ambition or jarring interests of the different chiefs. The more powerful princes frequently oppress their weaker neighbours; and in the fertile districts of the country extensive monarchies have arisen from conquest or religious prejudices, on the ruin of the smaller states. Of these are the dominions of the sherif of Mecca, of the imams of Sana and Mascat, and of several princes in the province of Hadramaut. In some cases these smaller states have associated for their common defence; and, from the disunion or hostility of its various tribes, the country has been in all ages a scene of rapine and intestine wars. In later times the rise of the Wahaby power crushed all the inferior chiefs, and on their ruins had arisen a powerful empire, which was overthrown by the Egyptian army of Mohammed Ali.

Administration of justice.

The Arabs, though they enjoy a rude independence, have made little progress in the arts and institutions of civil life. In administering justice, they resort to the most barbarous expedients. The scheik has not the power of enforcing obedience to any sentence if it is not agreed to by the parties. The kady, so often mentioned by the Arabian writers, is the only judge; and such of them as still remain are famed for being expert in the laws and customs of the nation, and for their integrity. The office of kady continues in one family, but is not confined to any individual, a choice being made of the fittest person in the family by the other kadys of friendly tribes, as well as by the people of his own tribe. The kady is paid by the litigating parties; but all the judges, especially those in towns, are open to bribery, and justice is sold to the highest bidder. In cases where the witnesses directly

[1] Burckhardt's *Travels in Arabia*, vol. ii. p. 127.

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contradict each other, some superstitious ordeal is used to discover the truth. A particular judge is appointed for cases which must be decided by supernatural means. He directs that a fire shall be kindled before him: "he then," says Burckhardt, "takes a long iron spoon, used by the Arabs in roasting coffee, and having made it red-hot in the fire, he takes it out, and licks with his tongue the upper end of the spoon on both sides. He then replaces it in the fire, and commands the accused person first to wash his mouth with water, and next to lick it as he had done. If the accused escape without injury to his tongue he is supposed innocent; if he suffer from the hot iron he loses his cause. The Arabs ascribed this wonderful escape, not to the Almighty protector of innocence, but to the devil." In all cases of manslaughter or murder where the fact is denied, this superstitious ordeal is appealed to, and no other mode of trial admitted. Where the parties refuse the decision of the judge, they resume their original right of avenging their own quarrel; and a strife of this nature once begun, and producing blood-shed, leads to a long series of cruel retaliations.

Among the Arabs crimes of every description are punished by fines; corporal punishments are entirely unknown; and there are no prisons to circumscribe the freedom of the desert. For every offence a fine is fixed in the kady's court, which is rigidly exacted: all insulting expressions or acts of violence, from a slight blow to wounding and the effusion of blood, have their respective penalties. They adopt the following singular mode of ascertaining the fine payable for killing a watch-dog: The dead dog is held up by the tail, so that its mouth just touches the ground; its length is then measured by means of a stick, which is fixed in the earth, and the offender is obliged to pour out over the stick as much wheat as will wholly cover it, which is then given to the owner of the dog. The form observed by an Arab in summoning witnesses is by exclaiming, "Bear thou witness, O ——;" or he may touch their arms with his hand, which is considered as a summons to give testimony. Where a party is accused of a crime, and there are no witnesses, the matter is referred to his oath. The judicial oaths of the Arabs have different degrees of sanctity; and for certain oaths they have a superstitious veneration, which induces them to tell the truth. One of the most common oaths is for a party to take hold with one hand of the middle tent-pole, and to swear "by the life of this tent and its owners." The following oath is often taken before the kady: A small piece of wood or some straw is presented to him who has to swear, with these words, "Take the wood, and swear by God, and the life of him who caused it to be green, and dried it up." Another oath, even more solemn, is the "oath of the cross lines," where the accuser leads the person accused of theft or any other crime to a distance from the camp, on account of the magical nature of the oath; and with his crooked knife drawing on the sand a large circle, with many cross lines inside of it, and obliging the defendant to place his right foot within the circle, he himself doing the same, he addresses him in the following words, which the accused is obliged to repeat: "By God, and in God, and through God, I swear I did not take it, and it is not in my possession."

A singular institution, that of the wady or guardian, prevails among the Arab tribes. An Arab may in the prime of life request a friend to act as guardian to his children. If he accepts the trust, his friend presents himself before him with a she-camel; and leading it over to him, says, "I constitute you guardian for my children, and your children for my children, and your grandchildren for my grandchildren." In this manner one family is constituted the hereditary protectors of another family; and thus this fierce and warlike community, the prey of continual dissension, is held together by its own peculiar ties, domestic as well as political. To the weak, such as minors, women, and old men, the system of guardianship affords some security, however imperfect, against the oppression of the strong.

The Arabs are naturally a jealous and haughty people. They betray the quickest sensibility to an affront or injury, and carry the principle of revenge to the greatest excess. They consider the redress of their own wrongs as equally a duty and a privilege; and there are certain affronts and trifling violations of punctilio, which can only be expiated by the blood of the offender. To spit beside another is considered an insult which must be avenged; and Niebuhr mentions the case of an Arab who was so highly incensed at one of his neighbours for accidentally spitting on his beard, that he was with great difficulty appeased, although the offender humbly asked pardon, and kissed his beard in token of submission. If one scheik says to another with a serious air, "Thy bonnet is dirty," or "The wrong side of thy turban is out," it is considered a mortal offence. Murder is the deepest injury that can be committed; and the Arab code regulates the revenge for blood by the nicest rules. It is a universal maxim, that he who sheds blood owes on that account blood to the family of the slain person; and this debt may be required not only from the actual murderer, but from all his relations. These claims constitute the right of *thár*, or of "blood revenge." In the case of a slain parent, the fifth generation of his lineal descendants inherit the sacred duty of avenging his blood on a corresponding series of descendants on the other side; and this right is never lost by prescription, but descends to the latest posterity. If the death of the person killed is retaliated on one only of the murderer's family, the account is considered to be cleared, though mutual hatred soon renews the quarrel. If two of the murderer's family be killed by the relations of the deceased, the former retaliates; "the interest and principal of the bloody debt," says the great Roman historian, "are accumulated; the individuals of either family lead a life of malice and suspicion; and fifty years may sometimes elapse before the account of vengeance be finally settled." But a murder may be compounded for money. The nearest relations of the persons slain may accept the price of blood, which varies among the different tribes from 1000 piasters, or L.50, to 500 piasters. Among the Aenezes the blood of one of the tribe is compensated by 50 she-camels, one riding camel, a mare, a black stone, a coat of mail, and a gun; though it is seldom that all these articles are required: that of a stranger by the price paid in the stranger's tribe. The matter being finally settled, a she-camel is brought by the homicide to the tent of his adversary, and there killed, the blood being supposed to expiate that of the person slain. The hostile parties feast upon this camel; and at parting, the homicide flourishes a white handkerchief on his lance, as an emblem of his purity from guilt. Some of the great scheiks, however, account it shameful, and contrary to the true spirit of the Arab law, to compound the price of blood; and they invariably refuse to commute into a fine the sacred duty of revenge. Niebuhr mentions that he was visited by an Arabian of distinction at Loheia, who was bound to avenge the murder of a relation, and who told him that he was often haunted in his sleep by the fear of meeting his enemy. In the course of the continual wars in which the Arabs are involved, debts of blood are frequently incurred. The blood of those who are killed in the heat of battle is required at the hands of their

enemies; and when any tribe violates the laws of war by slaughtering their enemies as they lie wounded on the field, the hostile tribe retaliate by killing double the number of their enemies with the same circumstances of cruelty; and hence long and bloody animosities frequently arise.

Tents. The tent of the Arab is covered with pieces of stuff made of goats' hair stitched together, which afford a complete shelter against the heaviest rain. The tent is divided into two parts, one for the men, and the other for the women, whose respective apartments are separated by a white woollen carpet of Damascus manufacture, drawn across the tent, and fastened to the three middle parts. The men's apartment is covered with a good Persian or Bagdad carpet; the women's apartment is the receptacle for all the rubbish of the tent, the cooking utensils, the butter, and water-skins, &c. The height of the tent is seven feet, its length from 25 to 30 feet, and its breadth about 10 feet. The articles of the tent consist of saddles and camel furnishings; large bags for holding water, made of tanned camel-skin; goat-skins for holding camel's milk, wheat-sacks made of wool or goat-hair; the leather bucket for bringing up water from deep wells; a large copper, the mortar, the hand-mill, wooden dishes, the coffee-pot, the iron chain which fastens the horse's fore-feet while he pastures about the camp. They have no chairs throughout the East, the universal practice being to sit cross-legged. In the Arabian towns the houses are built of stone, and have always terrace roofs. The houses of the tribes on the banks of the Euphrates are formed of the branches of the date-tree, and have a round roof covered with rush mats.

Dress. The dress of the Arabs is a coarse cotton shirt, over which the wealthy throw a long gown of silk or cotton stuff. Most of them, however, only wear over their shirt a thin, light, and white woollen mantle, or one of a coarser or heavier kind, striped white and brown. The mantles worn by the scheiks are interwoven with gold, and sometimes may be worth L.10 sterling. Some of the most considerable tribes, as the Aenezes, do not wear drawers, which are reckoned shameful for a man; and they usually walk and ride barefooted, even the richest of them, although they greatly esteem yellow boots and red shoes. They wear on their head a square kerchief of cotton: a few rich scheiks wear shawls of Damascus or of Bagdad manufacture. In winter they wear over the shirt a pelisse made of several sheep-skins stitched together. Many wear these skins even in summer, as they are taught by experience that thick clothing is a defence against the sun's rays. The Arab endures with wonderful constancy the extremes both of heat and cold. In winter he sleeps barefooted in an open tent, where the fire is not kept up beyond midnight; and in summer on the burning sand, under the intense rays of the sun. The dress of the women consists of a wide cotton gown of a dark colour—blue, brown, or black—and on their heads a kerchief. Silver rings are much worn by the Aencze women, both in their ears and noses. They wear glass or silver bracelets, of various colours, round their wrists and their ancles, and silver chains about the neck. They go barefooted at all seasons. The women wear over their faces a dark-coloured veil, which conceals the mouth and chin. Near Mecca and Tayf, and beyond these places southward, both men and women dress most commonly in leather. They both wear a leather apron round their loins, the women a larger one than the men, reaching down to their ancles, and adorned with many tassels. In summer the men wear no other clothing.

Diet. The diet of the Arabs consists everywhere of flour and butter, variously made ready. Unleavened paste of flour and water, baked in ashes of camel's dung, and mixed up afterwards with a little butter, and thoroughly kneaded, is served up in a bowl of wood and leather. Flour and sour camel's milk, made into a paste and boiled (*thé ayesh*), is the daily and universal dish of the Aenezes. Bread baked in cakes is used at breakfast. Bread, butter, and dates, are also mixed together into a paste. *Burgout*, the common dish of the Syrian Arabs, is wheat boiled with some leaves, and then dried in the sun; it is preserved for a year, and served up with butter and oil. The Arabs never indulge in luxuries, except on a festival, or the arrival of some stranger; and the richest scheik would think it a shame to order his wife to dress any rare dish merely to please his palate. For a guest of distinction a kid or lamb is prepared, and for one of less consideration coffee or bread with melted butter. In Hedjaz, or the hilly district of Arabia near the Red Sea, the usual dish is Indian rice, mixed with lentils, and without any bread; and in the districts where the date grows it forms the chief sustenance of the inhabitants. In Nedjed, Hedjaz, and Yemen, the Arabs use butter to excess. They frequently swallow a whole cupful of butter before breakfast, and all their food swims in butter. The constant exercise and motion to which they are accustomed so strengthens their powers of digestion, that they can endure without injury the extremes of excess and want. They can live for months on the smallest allowance, or devour at a sitting the flesh of half a lamb. Butter is made from the milk of sheep and goats; but never, except in cases of necessity, from that of camels. Among many of the Arab tribes it is considered shameful to sell any butter, or among the Bedouins near Mecca to sell milk; yet the Beni Koreish, one of the most noble of the Arabian tribes, freely supply the inhabitants of Mecca with milk.

Hospitality. Hospitality, the virtue of rude nations, is practised among all the Arab tribes, and no violation of its duties was ever known. When a stranger alights at the tent, the host, or in his absence the wife or daughter, spreads a carpet for him and prepares the hospitable meal. If he remains any time his aid is expected in the domestic business of the tent, in fetching water, milking the camel, or feeding the horse. But he may neglect these duties and still remain, though he will be censured for ingratitude; or he may go to another tent, where he will receive a hearty welcome; and every third or fourth day may change his residence, and be comfortably entertained during his stay, however long it may be. The greatest insult that can be offered to an Arab, is to tell him that he does not treat his guests well. Among some tribes women never eat or drink coffee in the presence of a man; and in this case some male relation, in the absence of the host, does the duties of hospitality. In the plain of Hauran, southward of Damascus, the wives and daughters of the Arabs may drink coffee with the strangers upon their arrival; and in the mountainous districts south of Mecca, towards Yemen, women are allowed, in the absence of their husbands, to entertain a guest, and to sit up with him.

Law of marriage. The Arabs are not so dissolute in their morals as most of the nations in the East. They are generally content with one wife: instances of conjugal infidelity are not common, and public prostitution is not seen in their camps. Yet they are far from being duly impressed with the sacred tie of marriage, which may be at any time dissolved at the pleasure of the husband; and this facility of divorce relaxes morality, though, to some extent, the manners correct the laws. A Bedouin, aware that a divorce is always in his power, contracts a temporary marriage of a few weeks; and it is not uncommon for a

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man, before he has attained the age of 40 or 45, to have had 50 wives. The wife also, if she is ill used, may fly for refuge to her father's tent, whence she cannot be reclaimed by her husband. Yet among the Bedouins many instances are found of conjugal fidelity and love. This rash dissolution of the marriage union is frequently fatal to the peace of one or of both parties. In 1815, Burckhardt mentions that a Bedouin of the Syrian desert, who had divorced his wife, and who was present at her second marriage, shot himself in a fit of distraction, the moment he saw the new husband enter the marriage chamber. The Wahaby ruler Saoud exerted all his authority to prevent the frequent divorces of the Arabs, by disgracing at court, or otherwise punishing, any man who either divorced his wife or used the expression *Aley et talak*, "I shall divorce," which, according to the Arab law or custom, cannot be revoked. Polygamy is permitted, but is not common, among the Arabs, owing chiefly to their poverty. The richer scheiks, however, indulge in a plurality of wives. The marriage ceremony among the Aenezes and most of the Arab tribes is extremely simple. The lover generally commences, through a common friend, a negotiation with the father of the girl; and if she is pleased, the friend, holding the father's hand, says, "You declare that you give your daughter as wife to ———;" to which the father assenting, the bridegroom comes on the marriage day with a lamb in his arms to the tent of his betrothed, and by cutting its throat before witnesses he completes the marriage ceremony. After the usual rejoicings the bridegroom retires after sunset to a tent at a distance from the camp, while the bride, in her maiden timidity, runs from tent to tent, struggling, kicking, and even biting those who attempt to conduct her to the bridegroom's chamber.

Rite of circumcision.

The rite of circumcision is still practised among the Arabs, and is the occasion of a great festival. All the boys are generally circumcised on the same day. Each man of the encampment kills at least one sheep in honour of his son, and the whole tribe feast on this abundant cheer. The men exhibit equestrian exercises and warlike evolutions; while the young women join in the national airs, and sometimes removing their veils, allow their lovers a hasty glance of their beauty as they pass. There are, besides, the festivals of Ramadhan and of the sacrifice of Arafat, where the same exercises are exhibited.

Mechanical arts, literature, music.

The Arabs are no great proficients in arts or industry, their only artists being a few blacksmiths to shoe the horses, and saddlers for the leather work. The arts of tanning and weaving are practised, the first by the men, the latter by the women. Of reading and writing all the Bedouins throughout Arabia are equally ignorant. The Wahaby chiefs were at pains to instruct them, and sent teachers among the different tribes, but with little effect. Nor have they made any progress in science or literature. In the first, their knowledge is confined to the names of the constellations and planets. Their literature consists in romantic tales of love and war, in which they delight; and the minstrel's strain frequently beguiles the evenings of an Arab encampment. Verses are recited or sung, and the voice is accompanied by a species of guitar, the only musical instrument which they possess. They have national airs also for female singers, which are chanted in choruses of six, eight, or ten voices, at some distance from the camp, in the solitude and silence of the desert. Many of the Arabian poets can neither read nor write, yet compose verses of exact measure, grammatically correct, and neither destitute of sentiment nor poetical beauty. Eloquence has from time immemorial been considered a necessary qualification of an Arab statesman: no scheik, however brave, can ever attain to influence among the Arabs without this talent. The language of Arabia is derived from the same original stock with the Hebrew, the Syriac, and the Chaldean tongues. Each tribe has its own peculiar dialect, but, by universal consent, the palm of elegance and purity has been, and still continues to be, assigned to the idiom of Mecca.

The preceding details exhibit in no very favourable view the moral character of the Arabs; and the boasted virtues of the desert, when they are calmly estimated, seem to resolve into the observance of certain rules or prejudices, without which no community can exist, however rude or lawless. The thieves and outcasts of civilized society are linked together by certain ties of good faith, without which all concert would be impossible even for their own evil ends; and the honour that prevails among the Arabs seems not to be of a much higher quality. They are, according to the accounts of all travellers, immoderately fond of gain, which they do not scruple to procure by the basest means. "Lying, cheating, intriguing, and other vices arising from this source, are as prevalent in the desert as in any of the market-towns of Syria; and on the common occasions of buying and selling, where his dakheil (oath) is not required, the word of an Arab is not entitled to more credit than the oath of a broker in the bazaar of Aleppo." An Arab will defend his guest at the peril of his own life; he will submit with resignation to the most cruel reverses of fortune; and at Mecca, during the pilgrimage, the true Bedouin of the desert, unlike the other pilgrims, disdains to ask alms, and always lives by his own industry, however precarious or humble. On the other hand, in pursuing the trade of rapine, he seems to be degraded, by his thievish, cruel, and treacherous habits, to the lowest rank of barbarism. In their familiar conversation the Arabs are free, sprightly, jocose, and decent. They are not reserved or silent, according to the report of some travellers, except perhaps in their journeys through the desert, where much speaking excites thirst, and parches the mouth. In their tents they are indolent, all that they do being to feed the horse, or milk the camels in the evening. The herds and flocks are committed to the care of a shepherd hired for the purpose; and the husband goes out to hunt with his hawk, or to amuse himself in any other manner that pleases him; while the wife and daughters are engaged in the household cares, in grinding the wheat with the hand-mill or pounding it in the mortar, in kneading and baking the bread, making butter, fetching water, working at the loom, or mending the tent-covering. They are patterns of industry, yet they are not allowed to eat with the men, and only partake in their own apartments (the *meharrem*) of what they leave. If a lamb is killed, they seldom taste, except some of the worst parts, which the men are not able to eat. This degradation of the women is common to the Arabs with other Asiatic nations, and is a true feature of oriental barbarism.

The small-pox continues to make serious ravages among the Bedouins, and to depopulate whole encampments. Inoculation is resorted to with benefit, and the practice of vaccination has extended over Syria. Obstructions and indurations of the stomach, occasioned by the use of camel's milk, are common; but these complaints are alleviated by the purging qualities of the brackish water of the desert: also fevers, both intermittent and inflammatory; and the burning with a hot iron is here, as in the former case, the approved cure. Ophthalmic disorders are frequent, and leprosy, which is hereditary in families, and cannot be eradicated. It consists of white spots, as large as the hand, which appear on various parts of the

body, without rising above the skin. If the white spots appear on the cheek, the beard commonly falls off: the unfortunate sufferer is held in universal disgrace. The toothache is unknown among the Arabs, who have all the most beautiful teeth.

The chief towns of Arabia are situated either on the coast of the Red Sea, or in the range of mountains which runs parallel to its shores. They are, Medina, with Yembo its sea-port; farther south, between 200 and 300 miles, Mecca, with Djidda, its sea-port; Tayf, east of Mecca; still farther south among the mountains, Sada, Sanaa, and on the coast of the Red Sea Gonfode, Loheia, Hodeida, and Mocha; Derayeh is in the interior, and Mascat on the coast of the Persian Gulf. The population of the towns consists chiefly of foreign traders, who follow the customs of the place, but seldom imbibe the national spirit. Hence they form an entirely different class from the Bedouin Arabs. They have their faults without their virtues, are dissolute in their manners, and addicted to the grossest vices. The commerce and religion of Arabia concur to bring together in the towns a mixed population from the most remote parts of the world.

Arabia has no manufactures, for a supply of which it is therefore dependent on its foreign trade. From its central position, however, and its contiguity to the shores of the Red Sea, in former times the only navigable communication between Asia and Europe, it has always been a great entrepôt for the commodities of other countries. In the ancient world it was the medium of intercourse between India and Europe, and still continues to enjoy a portion of this commerce.

The sea-port of Djidda, on the Red Sea, seems to be the great emporium of the Arabian trade. Thither resort the annual fleets from Calcutta, Surat, and Bombay, about the beginning of May. They bring piece goods, Cashmere shawls, cocoa-nuts, rice, sugar, drugs of all sorts; small articles of Indian manufacture, such as china-ware, costly collections of which are often displayed by the rich inhabitants; hardware, pipes, beads, wooden spoons, glass beads, knives, rosaries, mirrors, cards, &c. These goods are mostly disposed of for cash to Indian houses, the most eminent of which are known to possess capital to the value of L.150,000 or L.200,000 sterling, while several inferior houses have capitals of L.40,000 and L.50,000. The Indian trade is carried on to a great extent, sales of entire ships' cargoes being frequently made in the course of half an hour, and the money paid down next day. From every port of the Red Sea traders repair to Djidda during this annual fair, and lay out all that they possess in the purchase of Indian goods, which rise in price immediately after the departure of the fleet, and are always sold to good account. From Djidda they are sent to Suez and Cairo, whence they are dispersed over Egypt and the shores of the Mediterranean. The returns from Egypt are made either in dollars or sequins, or in produce or goods, such as wheat, for which Arabia depends on Egypt; tobacco, coffee, and butter, in the use of which articles all classes in Arabia indulge to excess; rice, biscuits, onions, soap; Bedouin cloaks, which are not manufactured in Arabia; inferior Turkish carpets, an indispensable article in the tent of every scheik; cotton quilts; linen for shirts, and other articles of dress; red and yellow slippers, used by the more opulent merchants, and by all the ladies, of which there is not one maker in any of the Arabian towns; red caps, all kinds of cloth dresses, Cashmere and muslin shawls; well-tinned copper vessels, a variety of which may be found in every Arabian kitchen; water-skins very neatly sewed, canvass, and cordage made of the date-tree. The Indian goods imported into Djidda are sent into the interior by the caravans, one of which departs for Mecca every evening during the season of the pilgrimage, and at other times twice a week, with goods and provisions. To Medina goods are partly sent by sea through Yembo, the sea-port, and partly by a caravan, which sets out regularly once in forty or fifty days, accompanied by a crowd of pilgrims on a visit to Mahomet's tomb.

Djidda is also the great entrepôt of the coffee trade. Ships laden with this article are constantly arriving from Yemen. The cargoes are generally disposed of for dollars, and are sent to Suez and Cairo for the supply of Egypt and the Mediterranean countries. This trade has been rather on the decline, Mocha coffee having been supplanted in the markets of European Turkey, Asia Minor, and Syria, by that produced in the West Indies. The importation of West India coffee into Egypt is now, however, strictly prohibited by the pacha Mohammed Ali. From Bagdad and Bosra Djidda receives large quantities of an inferior species of tobacco, called tombak; also a supply of tobacco-pipes, on which the Arabs, being extremely curious, expend large sums of money. From Abyssinia musk is brought by the inhabitants in horns, and in return they receive Indian glass beads, which are in great request all over Africa. Ships arrive from Mascat in the Persian Gulf, and from Bassora, with the produce of the adjacent countries, and slave-vessels from the coast of Mozambique. From the interior supplies of corn are received, as well as a great variety of fruits, especially the date, which for a part of the year is the common food of the people in Arabia. It is made into a sort of paste, and is exported to the East Indies and to other countries, where it is sold to great profit among the Mussulmans of Hindostan. The fine almonds and raisins produced in the gardens of Tayf are also taken in considerable quantities by the Indian fleet.[1] Honey, which abounds in the mountainous parts, and of the best quality, is exchanged by the Arabs for manufactures. The celebrated balm of Mecca, so difficult to be obtained in a pure state, is another article of trade; and in adding to that the milk and the wool yielded by the flocks and herds, we sum up the whole surplus produce which the Bedouins have to give in exchange for other articles. Djidda is the great shipping port of the Red Sea, to which belong 250 vessels; yet no vessels are built here, the scarcity of timber being so great that a ship can scarcely be repaired either here or at Yembo. Suez, Hodeida, and Mocha, are the only harbours at which ships are built, and the timber is transported from Asia Minor, Yemen, or the African coast.

In Arabia, as in most other eastern countries where property is not protected, capital is slowly accumulated, and is in general far from abundant. The rate of profit is consequently high, amounting to 30, 40, or even to 50 per cent. No money can be lent out at interest as in Europe, it being contrary to the law of the Koran, and no one besides having confidence in another. There is no monied interest in Arabia. There are no stocks of any description, or public funds, in which money can be invested; and every capitalist is therefore engaged in trade, from which he never can withdraw to live on his money as in Europe. Credit is with difficulty obtained, and trade is carried on by means of barter or by sales for cash. Hence no Arabian merchant can contract debts which he is unable to pay; and there are consequently no mercantile failures in Arabia as in Europe.

[1] See Niebuhr, sect. vi. chap. v.; Burckhardt's *Travels in Arabia*, vol. i.

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Pilgrimage to Mecca.

Mecca and Medina, besides being places of trade, are the two holy cities, to the former of which a visit is enjoined by the prophet on every pious Mahometan who can afford the expense. A visit to the tomb of Mahomet at Medina, though it is not strictly commanded, is still reckoned a highly meritorious part of the same holy pilgrimage. In obedience to this summons, which is heard throughout the wide precincts of the Mahometan world, crowds of devotees, to the number frequently of 70,000 or 80,000, ambitious of the honourable title of hadjy or pilgrim, arrive at Mecca during the fast of Ramadhan, from the most remote quarters of the earth; from European Turkey and Greece; from the countries on the shores of the Mediterranean, namely, Syria and Palestine on the east, and the Barbary States on the south; from Timbuctoo, Soudan, and the depths of Central Africa; from Persia; from the regions of the Indus; and from Hindostan, Malacca, and the Asiatic Isles. So vast and various an assemblage of strangers collected into one city, from all the different nations of the East, forms a most singular spectacle, and is a striking proof of the power and extensive influence of the Mahometan faith. The crowds who resort thither consist of all classes of Mahometans. The proud noble, the rich merchant, the bashaw, and the prince in all the pomp of wealth and dignity, are mingled in the religious ceremonial of the holy city with the common crowd of poor pilgrims, the wretched and servile Hindoo, or the poor but independent negro of Soudan, who, as a mendicant or a labourer, makes his way for thousands of miles through unknown lands and hostile tribes. In arriving at the holy city, it is the duty of the pilgrims, before attending any worldly business, to visit the Beitullah or temple, which at night is brilliantly lighted up with lamps; to walk seven times round the kaaba or black stone, said to be brought down from heaven by the angel Gabriel, and to touch or to kiss it; to drink water, or wash in the holy well of Zemzem, miraculously created for Hagar and her son Ishmael; to proceed to Mount Arafat, distant from Mecca about 20 miles, and to be present from afternoon till sun-set at a sermon preached on that holy spot; to sacrifice a sheep in the valley of Muna, or to substitute, if the pilgrim be poor, a fowl at some future period; and, after several other ceremonies, many of them, such as throwing stones at the devil, sufficiently absurd, to return to Mecca, and to revisit the kaaba and the omrah.[1] The Mahometan religion is not of a gloomy or ascetic cast, and the pilgrimage to Mecca is not undertaken in this spirit. On the contrary, the visit of the pilgrims to Mount Arafat, in which they are joined by almost the whole inhabitants of Mecca and Djidda, resembles not so much a religious ceremony as a holyday festival, in which all ranks indulge in revelry and show. The common people assemble in their best suits, as if to enjoy a splendid spectacle; and the rich and luxurious vie with each other in the splendid pageantry of their retinue and equipages. The whole crowd of pilgrims—tribes and tongues from all parts of the Mahometan empire, of the most various costumes, manners, and aspect, with their accompanying train of camels, dromedaries, and horses—press forward on the appointed day to the plain of Arafat, and present a scene so animated and impressive, and exhibiting such a picturesque variety of nations in so small a space, that it is certainly without a parallel in any other part of the globe. Burckhardt is the only European traveller who has ever been present at this great festival of the Mahometan faith; and his details are extremely interesting and curious. "Of the half-naked hadjys," he observes, "all dressed in the white ihram, some sat reading the Koran upon their camels, some ejaculated loud prayers, whilst others cursed their drivers, and quarrelled with those near them who were choking up the passage." On the plain of Arafat the mixed multitude encamp according to a certain order, each nation occupying its appointed place; and at night the fires which blaze throughout the encampment, and the arched and brilliant clusters of lamps which are lighted before the tents of distinguished pilgrims, illuminate the plain, and give a peculiar brilliancy to the scene. In the pilgrimage of 1814 Mohammed Ali the pacha of Egypt, Solyman the pacha of Damascus, and the mother of Mohammed Ali, were the most conspicuous for their rank and splendour. The latter arrived from Cairo with a princely equipage, her baggage being transported by 500 camels from the sea-coast of Djidda to Mecca. "Her tent," says Burckhardt, "was in fact an encampment, consisting of a dozen tents of different sizes, inhabited by her women; the whole inclosed by a wall of linen cloth 800 paces in circuit, the single entrance to which was guarded by eunuchs in splendid dresses. Around this inclosure were pitched the tents of the men who formed her numerous suite. The beautiful embroidery on the exterior of this linen palace, with the various colours displayed in every part of it, constituted an object which reminded me of some descriptions in the Arabian Tales. Among the rich equipages of the other hadjys or pilgrims, or of the Mecca people, none were so conspicuous as that belonging to the family of Djeylany the merchant, whose tents, pitched in a semicircle, rivalled in beauty those of the two pachas, and far exceeded those of Sherif Yahya." On the following day the encampment is again broken up, the tents are struck, every thing is packed up, and the immense crowd, either on foot or mounted on camels and horses, throng round the mountain of Arafat to hear the sermon, an essential part of the ceremony, which is preached in the afternoon. The preacher, mounted on a finely caparisoned camel, harangues the multitude, most of whom are deeply affected, weeping and beating their breasts, and denouncing themselves to be great sinners before the Lord; while others are fixed in silent adoration, with tears in their eyes. The preacher reads his sermon from a book in Arabic. "At intervals," Burckhardt adds, "of every four or five minutes, he paused and stretched forth his arms to implore blessings from above; while the assembled multitudes around and before him waved the skirts of their ihrams over their heads, and rent the air with shouts of 'Lebeyk, Allah huma Lebeyk,'—Here we are at thy commands, O God!" The natives of the towns and the Turkish soldiers were in the mean time conversing and joking, and, while the more fervent devotees were waving the ihram, derided that ceremony by violent gesticulations in imitation of them. The preacher, when the sun descends behind the western mountains, concludes his discourse and closes the book, when the whole multitude of pilgrims make their way over the plains at a quick pace in the greatest tumult and disorder, with a clamour that is quite astounding, and encamp, after a journey of two hours, where another sermon is heard that lasts from daybreak till sunrise of the following day. They then move, on the 10th of Zul Hadjy, towards the valley of Muna, 1500 paces in length, and inclosed on both sides

[1] In visiting Mecca it is the practice of the more strict devotees to assume the *ihram*, a garment consisting of two pieces of linen woollen, or cotton cloth, one of which is wrapped round the loins, and the other thrown over the neck and shoulders, leaving the right arm uncovered. The head remains totally uncovered. All other garments must be put off, even at night, when the ihram is assumed. The use of this dress, whether in summer or in winter, is found extremely inconvenient and prejudicial to health.

by steep and barren cliffs of granite. Here they offer the sacrifice of a sheep; repair to the barber's shop, where their heads are shaved; throw at the devil 21 stones; and lay aside the ihram, their pilgrimage being so far completed. A new scene now commences. Almost all the pilgrims who visit the holy city have goods to dispose of, from which they hope to defray the expenses of the journey. The rich hadjys bring in the caravans large stores of merchandise, which they barter with the great merchants of Djidda who reside in Mecca, for Indian goods; and the poorer pilgrims have all some small stock of articles, the produce or manufacture of their respective countries, which they also propose to sell or exchange in this great resort of religion and of trade. The influx of such a vast multitude of strangers, with about 20,000 or 30,000 camels, gives a stimulus to several branches of internal commerce. It creates a great additional demand for provisions, for lodgings, and for other articles of necessary use; and, accordingly, every inhabitant of Mecca who can scrape together the smallest sum lays it out during the pilgrimage in some adventure, however inconsiderable. With pious objects other pursuits are in this manner associated of a less spiritual nature; and the pilgrimage to Mecca is in reality a great annual fair, to which merchandise is brought from all parts of the world. This fair continues in the valley of Muna three days, from the 10th to the 12th of the month of Zul Hadjy. A row of buildings, mostly in ruins, are occupied by the Meccans or Bedouins for the purposes of trade during these three days, while every inch of ground not built upon is occupied by sheds or booths made of mats, or by small tents, where provisions and merchandise of all kinds are exposed to sale. The great merchants who travel with the Syrian caravans exhibit samples of the articles which they have brought for sale or to exchange for Indian goods, while the poorer pilgrims are crying their small adventures through the streets. After the return to Mecca business is still prosecuted with equal ardour by the pilgrim adventurers, and the town is so crowded that the principal street is almost impassable. The Syrian merchants hire shops, where they trade with activity till the departure of the caravans for Syria and Egypt, which takes place after a stay in the town of ten days.

The inhabitants of Mecca derive their subsistence either from trade or from the service of the mosque, which occupies a numerous body of individuals. These are maintained by fixed salaries remitted from Constantinople, and they also share in the presents made by the richer pilgrims to the temple. In the more fervent ages of Mahometanism the temple of Mecca drew its revenue from the various towns and districts of the Turkish empire, and large presents were received from the kings of Hindostan and other eastern countries; but those revenues have been discontinued, and the mosque is now solely supported from the Turkish treasury. The sum allotted for this purpose is distributed among its officers, according to their rank or services. The name of every servant of the mosque is inscribed in a register at Mecca, of which a duplicate is sent annually to Constantinople, where the name is also enrolled; and the whole sum is made up in small packets and sent to Mecca, each indorsed with the name of the individual for whom it is designed. They are distributed by the kady of Mecca, in the mosque, after the departure of the pilgrims, and they amount from one piaster annually to 10, 20, and in a few cases to 2000, equal to about L.50 sterling. The tickets which entitle those persons to a pension are transferable, the transfer being signed by the kady and the sherif; and they form a species of stock, which is bought and sold in the money market of Mecca. By the extension of the Wahaby power in Arabia the intercourse of the pilgrim caravans with the holy city was interrupted, and the holders of those tickets had not for eight years received any pay. Their value was consequently lowered, though it has been again somewhat raised since the overthrow of the Wahaby power by Mohammed Ali, and the return of the caravans. But some of the tickets were even after this sold at two and a half years' purchase, which evinces no great confidence in the stability of the Turkish conquests.

At Mecca guides are required to all the holy places which it is incumbent on the pilgrims to visit. These form the most idle and profligate class of persons in Mecca, and they practise on the pilgrim every species of knavery. The guide, or delyl as he is called, besieges his room from sunrise to sunset; he obtrudes his advice; he sits down with him to breakfast, dinner, and supper; he is always asking him for money, always leading him into expense; and if he act as interpreter in any mercantile concern, he is sure to betray the poor ignorant Turk who trusts him. The following description by Burckhardt, of his own delyl or guide, may, he says, be taken as a general picture of the lower classes of Mecca. "He sat down," he observes, "regularly at dinner with me, and often brought a small basket, which he ordered my slave to fill with biscuits, meat, vegetables, or fruit, and carried away with him. Every third or fourth day he asked for money. 'It is not you who give it,' he said, 'it is God who sends it to me.' Finding there was no polite mode of getting rid of him, I told him plainly that I no longer wanted his services—language to which a guide is not accustomed. After three days, however, he returned, as if nothing had happened, and asked me for a dollar. 'God does not move me to give you any thing,' I replied; 'if he judged it right he would soften my heart, and cause me to give you my whole purse.' 'Pull my beard,' he exclaimed, 'if God does not send you ten times more hereafter than what I beg at present.' 'Pull out every hair of mine,' I replied, 'if I give you one pera until I am convinced that God will consider it a meritorious act.' On hearing this he jumped up and walked away, saying, 'We fly for refuge to God from the hearts of the proud and the hands of the avaricious.'" At Cairo the following proverb is used to repress an insolent beggar. "Thou art like the Mekkawy:" thou sayest, "Give me, and I am thy master."

From so great an annual concourse of opulent strangers and traders, and from the presents and stipends of the richer pilgrims to their guides and to the servants of the temple, great wealth flows into Mecca, which should be among the richest cities of the East. But, with the exception of the first merchants, who seldom spend their great gains though they live in splendour, their tables being furnished every day with the rarest delicacies, the inhabitants of Mecca are dissolute and luxurious in their habits. The departure of the pilgrims is succeeded by the marriage and circumcision feasts, on which all that has been gained during the last three or four months is frequently squandered away. The women give the most profuse and magnificent entertainments, while the men waste their means in the purchase of female Abyssinian slaves, and in other indulgences still more vicious and degrading. The utmost profligacy of manners prevails in all the Arabian towns, as indeed in all Mahometan countries; and the holy temple, the very sanctuary of the Mahometan religion, is daily profaned by the grossest depravities, to which no shame is attached. The young of all classes are encouraged in those immoralities by the old; and even parents connive at the disgrace of their children, and profit by their iniquities. From such vices the en-

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campments of the Bedouin Arabs are alone said to be exempt.

Medina is also a holy city, containing the mosque, with the tomb of the prophet, which is visited during the whole year by crowds of pilgrims, though this pilgrimage is not, like that to Mecca, a sacred duty. The tomb was the receptacle of the pious offerings of the pilgrims, consisting of precious jewels, ear-rings, bracelets, and other ornaments; and it contained also several magnificent manuscripts of the Koran. These were carried off by Saoud, the Wahaby chief, when his armies entered Medina; and part of the precious spoils were presented to Mohammed Ali, by Abdallah his son, when he was prisoner in Egypt. The service of the mosque at Medina is provided for in the same manner as that of the temple at Mecca; its officers are more respectable and of higher rank, and greater decorum is everywhere maintained.

History.

Arabia has been peopled from the earliest times, but its ancient history seems to have been lost or corrupted in a long course of oral tradition. The narratives of the Arabian historians are absurd and fabulous, resting on no evidence; nor have later writers succeeded in withdrawing the veil of oblivion from the history of those early ages. The common notion among the Arabs is, that they are descended from Joktan the son of Eber, as well as from Ishmael the son of Abraham by Hagar; and the posterity of the former are denominated pure Arabs, while those of the latter are called *naturalized* or *insitious* Arabs. Joktan had thirteen, or, according to the Arabian traditions, thirty-one sons, who, after the confusion of languages at Babel, are said to have settled in the south-eastern parts of Arabia, and to have gone afterwards to India, with the exception of two, namely, Yarhab and Jorham, the former of whom gave name to the country. Yarhab settled in Yemen, while Jorham founded the kingdom of the Hedjaz, where his posterity reigned. Ishmael being dismissed by Abraham, retired to the wilderness of Paran, where he married an Egyptian, by whom he had twelve children, who were the heads of as many potent tribes of the *Scenite* or wild Arabs. He afterwards, according to tradition, married the daughter of Modad, the king of the Hedjaz, lineally descended from Jorham; and is thus considered by the Arabians the father of the greater body of their nation.[1] By these tribes Arabia was ruled in ancient times, and a genealogical list is preserved of a long line of kings in Yemen and other provinces, of whom nothing further is known than the names. The ancient tribes who inhabited Arabia maintained flocks and herds. They were addicted to commerce and rapine, and frequently by their inroads molested the neighbouring states. They were invaded in their turn by the Assyrians, the Egyptians, the Medes, and the Persians; but whatever ancient historians may relate concerning the victories of Sesostris, it does not appear that either the Assyrians, the Egyptians, or the Persians, ever obtained any permanent footing in the country.

The Greek and Roman writers describe with accuracy the general features of Arabia, the scarcity of water in the desert, the deep wells known only to the inhabitants, and the pastoral and predatory habits of the people; and, in the fertile districts, the rich produce of corn, wine, oil, honey, frankincense, myrrh, and odoriferous gums. But this authentic information is mixed with fabulous tales and absurd exaggerations. From the rare and precious produce with which Arabia abounds, the most fanciful ideas were formed of its vast wealth. It was said to possess abundant mines of precious stones, and gold, which was found in small pieces of the size of nuts, of the brightest colour and polish. (Diodorus Siculus, *Hist.* lib. ii. sect. 48). This favoured land was besides supposed to be enriched by the peculiar nature of its commerce, its valued products being sold to other nations, while their produce was not required in return. The balance of trade was thus always in its favour; and, according to this hypothesis, a supply of gold and silver was perpetually flowing into it from all other countries.[2] Cassia and cinnamon are also erroneously mentioned as the products of Arabia, probably because they came directly to the Romans from that country, which has been in all ages the great depot of Indian produce. The great lake, mentioned by the ancient writers, and said to contain bitumen, and to yield a large revenue, must be the Dead Sea, thus included by the ancients within the limits of Arabia; or the existence of this sea so near Arabia may have given rise to the report of another lake in the interior, which we know does not exist. Pliny says that the inhabitants shave their beards, with the exception of the upper lip—a custom which, if it ever existed, has not been transmitted to the modern Arabs, who hold the beard in peculiar honour; and the story of their promiscuous cohabitation, related by Strabo and Ptolemy, is entirely contradicted by all the latest and most authentic accounts of Arabian manners.

In describing the zoology of Arabia, the ancient writers give an accurate account of the camel and the dromedary; but some of them assert that the country contains no horses, for which in modern times it has been so famed; and their description of the ostrich is altogether fabulous and absurd. Pliny asserts that it exceeds the height of a man on horseback; Diodorus, that it is of the size of a new-born camel, that it throws stones with its feet at its pursuers, and adds various other equally unfounded details of its habits and the manner of its death. Ptolemy was the first writer who divided Arabia into three parts; namely, Arabia Petræa, Arabia Deserta, and Arabia Felix; which division, agreeing with the natural features of the country, is still recognised. Ptolemy, and also Pliny, give a long list of towns, and of the various tribes which ranged over the country. These have mostly disappeared; and the situation of Petra, the chief fortress of Arabia Petræa, is a subject of dispute among the learned. The nations who inhabited this tract were the Ishmaelites, the Nabatheans, the Cedrei or Kedareni, and the Hagareni, all which appellations have in later times been lost in that of the Saracens, so celebrated for several centuries all over the East. Numerous towns are mentioned in Arabia Deserta, of which, being originally of little note, all knowledge is now lost; and of the tribes of the Æsitæ and the Agræi we know nothing but the names. Arabia Felix was the chief seat of population and of wealth. It included the fine provinces of Yemen, Hedjaz, Tehama, Nedjed, and Yumama. It was inhabited by many different tribes, such as the Sabæi, who, from the account of Pliny, were a powerful tribe, trading in frankincense, and extending from sea to sea, either from the Red Sea to the Indian Ocean, or to the Persian Gulf;[3] by the Minæi, Atramitæ, Marinatæ,

[1] *Universal History*, vol. viii. chap. ix.

[2] Plin. *Historia Naturalis*, lib. vi. cap. 32. "In universum gentes ditissimæ, ut apud quas maximæ opes Romanorum Parthorumque subsistant, vendentibus quæ e mari aut silvis capiant, nihil invicem redimentibus." Strabo (lib. xvi.) mentions that they sold their gums for precious stones and for gold; and that the invasion of Arabia under Augustus, by Ælius Gallus, was prompted by the desire of attaining the alliance of rich friends, or the conquest of rich enemies. If these ancient writers had been versed in the modern doctrines of political economy, they would have known that the balance of trade could not have been permanently in favour of a country which abounds in gold.

[3] "Sabæi Arabum propter thura clarissimi, ad utraque maria porrectis gentibus." Plin. *Historia Naturalis*, lib. vi. cap. 32.

Catabani, Ascitæ, Homeritæ, Sapphoritæ, Omani, Saraceni, &c. of whose history nothing is now known. The towns of Yaman or Yemen were, Aden, the *emporium Arabiæ* of Ptolemy, on the Indian Ocean; and Musa, the modern Mocha; both noted marts of trade, at which were exchanged the precious produce of the country (consisting of myrrh, frankincense, perfumes, and pearls, of which there was a noted fishery near some islands in the Red Sea), for goods brought by the annual fleets from India. Those goods appear to have been landed at Aden or Musa; to have been carried northward in caravans to Leucocome, or Portus Albus, in lat. 25° N.; then, according to Strabo, to have been transported across the Red Sea to Myos Hormos, near the modern Cosseir; and being carried on camels to Coptos, in the Thebaid, a port on the Nile, to have been thence floated down in boats to Alexandria. Sanaa, the capital of Yemen, of great antiquity, is supposed to be the Saphor of Ptolemy; and Mareb, the modern Saba, which was a large, opulent, and strong city, is now an inconsiderable village. On the Persian Gulf was situated the port of Moscha, now the city of Mascat; and Gerra or Khatif, which, Pliny and Strabo mention, had turrets and houses formed of square masses of salt, some of which are still to be seen in the country. In the Hedjaz was Macoraba or Mecca, the seat of a very ancient temple; and Yathrib or Lathrippa, the modern Medina. Djidda, the port of Mecca, is seldom noticed by the ancients; and Yembo, the port of Medina, is the Jambia of Ptolemy. The frequent incursions of the Arabs into the neighbouring regions exposed them to retaliation from hostile armies; but the aridity of the country was found to be still its true defence. It was in vain that the invader vanquished the Arabs in the field; they fled from his pursuit on their horses and camels, and quickly disappeared in the burning desert, whither no army ever dared to follow them. The northern provinces bordering on Syria were invaded by Antigonus, and afterwards by Pompey, though they never succeeded in acquiring possession of Petra, the great stronghold of the country. But the most important expedition of the Romans was that of Ælius Gallus, in the reign of Augustus, who, with a force of 10,000 troops, of whom 500 were Jews, and 1000 Nabatheans, natives of the country, landed at Leucocome, in latitude 25° N., about 70 miles north-west from Medina, and in the following spring, his troops having been till that time disabled by disease, he advanced southward, crossed a desert of 30 days' journey, and in 50 days more arrived in a pleasant and fruitful region, where he took by assault a city called Najran. He continued his march southward for other 60 days; and being finally compelled to retreat by fatigue and disease, he crossed the Red Sea, and, landing his troops at Myos Hormos, on the Egyptian shore, brought back the poor remains of his army to Alexandria, after an absence of two years.[1] The situation of the towns in his route being entirely unknown, we cannot trace his course, though it must have been in the direction of Medina and Mecca. The great historian of the Decline and Fall of Rome places the march of Ælius Gallus between Mareb or Mecca and the sea.[2] But this is a desert tract, in no respect resembling the character given of the country into which he penetrated, which may therefore probably be the elevated tract on the Hedjaz ridge of mountains, extending north and south parallel with the Red Sea. Northern Arabia was also invaded by the emperors Trajan and Severus, but they effected no settlement in the country; and though the cities of Bosra and Petra were at one time reduced by a lieutenant of Trajan, yet the Romans never seem to have extended their power over Arabia Petræa. On the decline of the empire Syria was invaded by the Arabian freebooters, who sometimes drew on themselves severe retaliation. The doubtful frontier of the respective territories was thus a constant scene of hostility, until the Arab tribes, inspired by the genius of Mahomet, advanced to permanent conquests.

Arabia afforded an asylum to the Jews who were scattered abroad by the destruction of Jerusalem, and to the Christian sectaries who were driven out of the Roman empire by their orthodox brethren. The Christian exiles introduced the Arian heresy among the Arabians, while the Jews spread their peculiar doctrines, and acquiring wealth by commerce, they built cities, enriched the country, and had become powerful among the tribes of Arabia, when they were exterminated by the sword of Mahomet.

Mahomet.

Such are some of the early traditions and imperfect sketches of Arabian history. We now approach a new era, not only of greater certainty, but containing events of far deeper interest, and of lasting importance. The rise and progress of Mahomet, the prophet of the East, and the rapid propagation of his faith, which has changed the moral and political aspect of the eastern world, forms a most singular chapter in the history of human affairs, of which we shall now endeavour to present the most important details. Mahomet was born in the 569th year of the Christian era. His lineal descent from Ishmael, the founder of the Arabian nation, is a fable of his disciples. Historians are agreed, however, that he sprung from the tribe of Koreish, and the noble family of Hashem. In the 40th year of his age he assumed the title of a prophet, and proclaimed the religion of the Koran, and the destruction of the ancient Arabian idolatry, namely, the worship of the sun, moon, and stars. The resort to Mecca as a holy place of pilgrimage was still continued, and he held in the same veneration as before the ancient temple and the square chapel of Kaaba, inclosing the black stone which the Mahometans suppose to have descended from heaven, round which the rude idolaters of Arabia walked seven times with hasty steps, and then kissed the sacred relic. The visit to the mountain of Arafat was also retained, and all the other minute observances connected with the pilgrimage already detailed. The temple of Mecca contained 360 idols of men and of animals. The rocks of the desert were carved into the same figures, or into altars in imitation of the black stone of the Kaaba; and in earlier times the Arabian altars were stained with human blood. In opposition to these idolatries, Mahomet proclaimed the unity of the Deity to be the basis of the new faith. He declared "that there is only one God, and that Mahomet is the apostle of God." For the adoration of saints, of idols, or of any sensible object, he substituted public worship by prayer, and a sermon in the mosque on the Friday of every week, as well as private prayers and daily lustrations; and the annual fast of the month of Ramadhan for 30 days, during which the Mussulman, from the rising to the setting of the sun, rigidly abstains from food or drink, from baths, perfumes, or any enjoyment that can refresh the body. Alms-giving was enjoined, and the use of wine was interdicted. The doctrines of toleration were maintained and practised for a time; but, with the power, the inclination to persecute was soon displayed, and the followers of the new faith were commanded to pursue unbelievers with fire and sword, and to extirpate the idolatrous nations of the earth. The first converts to

[1] Dion Cassius, *Hist. Rom.* lib. liii. sect. 29.

[2] Gibbon, vol. ix. chap. 50.

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the doctrines of Mahomet were his own family; his wife Cadijah, her friend, his servant Zeid; afterwards Ali, the son of Abu Taleb, his uncle; and in three years fourteen other proselytes. Mahomet, by openly preaching to the people, and upbraiding them with their idolatry, obstinacy, and perverseness, drew on himself their hostility; and his life was threatened by the rival tribe of Koreish, who had been long jealous of the pre-eminence of the Hashemites, the hereditary guardians of the Kaaba and the holy temple. The death of Abu Taleb, his uncle, left him exposed to the malice of his enemies, who now resolved to take his life by dispatching a person from each tribe to bury a dagger in his breast; thus to divide the guilt of blood, and by their union to baffle the vengeance of the Hashemites. Mahomet, apprized of this conspiracy, with his friend Abubekr escaped to the cave of Thor, where he lay concealed for three days; and finally to Medina, into which city he made his public entry sixteen days after his flight from Mecca, and was hailed with the acclamations of the faithful people. From this memorable event is dated the Mahometan era of the Hegira or Flight, which coincides with the 16th July A. D. 622. Assuming the office of pontiff and of king, he was soon surrounded by a devoted band, who were impatient to die as martyrs in his cause. His early exploits were against the trading caravans between Syria and Mecca; and his first battle, in which he defeated, at Beder, Abu Sophian, his enemy, the leader of the unbelieving Koreish, was fought in defence of a rich caravan. In the second battle, which he fought on Mount Ohud, six miles to the north of Medina, the Koreish, to the number of 3000, advancing in the form of a crescent, their right led on by Khaled, a name afterwards so terrible to the infidels, were broken by the fierce attack of Mahomet's resolute band, who, rashly pursuing their advantage, while 50 archers posted in the rear as a reserve at the same time quitted their ground to plunder, the Moslem army was in its turn attacked and overthrown by Khaled. Mahomet, wounded in the face with a javelin, and having two of his teeth shattered with a stone, while Khaled exclaimed in the fury of his attack that he was slain, as were seventy of his followers, and among them Hamza the prophet's uncle, and Mosaab the standard-bearer, still succeeded, though with difficulty, in rallying his broken forces, and in effecting a retreat. In the following year Abu Sophian, with a combined army of Arabs and Jews, sat down before Medina, when he was obliged to retreat after a siege of twenty days. Mahomet, thus secure of his conquests, rapidly subdued the surrounding tribes. The numerous Jews who dwelt in Medina and the neighbourhood, rejecting the proffered faith of the prophet, were either put to the sword or made captives. The Khoreidhites were extirpated after a resistance of twenty-five days; and the ancient and flourishing city of Chaibar, the seat of the Jewish power, was reduced after a fierce resistance. Torture was applied to the chief in the presence of Mahomet, to extort from him a discovery of his hidden treasures. The captives were massacred; and, by the savage vengeance of the conquerors, 700 prisoners were buried alive.

But it was to Mecca, the holy city, that Mahomet's longing eyes were directed; and, confident from recent conquests, and still farther strengthened by the conversion of Khaled and Amrou from active and formidable enemies to zealous friends, he now aspired to the conquest of this last remaining stronghold of the infidels in Arabia. He had concluded a truce for ten years with Abu Sophian, for the violation of which a pretext was sought and easily found; and he now advanced, at the head of 10,000 troops, to crown all his former achievements by the conquest of Mecca. So secretly had he taken his measures, that the first warning of danger was his approach to the city gates. The intrepid Khaled routed a large body of the Koreish in the adjacent plain, and hotly pursuing the fugitives into the city, massacred a number of the inhabitants, and so alarmed the survivors that they were glad to capitulate, and to deprecate the vengeance of the conqueror by a profession of the new faith. Mahomet made his public entry into the holy A. D.
city at sunrise. He walked seven times round the Kaaba, touching with his staff the black stone as he passed. He destroyed the 360 idols of the temple, prohibited for ever the idolatries of the Koreish, and ordained that no unbeliever should henceforth profane the holy city by his presence. The conquest of Mecca was followed by the submission of other Arabian tribes. Some made resistance, but were subdued; and in the end the whole peninsula yielded faith and obedience to the prophet's creed and to his victorious arms. Mahomet, thus crowned with victory, was overtaken by a fever at Mecca, and expired A. D. 632, in the 62d year of his age. His death exposed the new state to the dangers of a disputed succession. The right to the throne, on which subject Mahomet was silent when he died, was respectively claimed by two powerful tribes, namely, those who fled to Medina with the prophet, or the *fugitives*, and those who aided him on his arrival, or the *auxiliaries*. To terminate this dangerous dispute, Omar, renouncing his own pretensions, held out his hand to Abubekr as his future sovereign; and his authority was recognised in all the provinces. The Hashemites, under Ali their chief, though averse to the new monarch, acknowledged him after some time as commander of the faithful. After a reign of two years he was succeeded by A. D.
Omar, who was assassinated in the 12th year of his reign, and was succeeded by Othman; and it was not till his death that Ali ascended the throne. This contest for the dignity of caliph has ever since divided the Mahometans into the two hostile parties of the Shiites or sectaries, who reprobate as usurpers Abubekr, Omar, and Othman; and the Sonnites, who revere them along with Ali as the legitimate successors of the prophet. This schism is the source of the hatred which still exists between the Persians and Turks.

Arabia, during the reign of these several princes, was filled with distraction at home, while the most splendid conquests were achieved abroad. To give a detail of these events, which relate besides to other countries as much as to Arabia, would exceed our limits. We may therefore briefly observe, that during the short reign of Abubekr, the Syrian territories of the Greek emperor were overrun by the victorious Moslems under Abu Obeidah, and afterwards under Khaled, surnamed from his valour and fanaticism the sword of God; that the Greek armies were overthrown in several decisive battles; and that the rich and populous cities of the country, including Bosra and Damascus, were stormed by the barbarian invaders. A new army, raised by the Greek emperor, the last hope of the falling empire, was scattered before the barbarian host in the decisive battle of Yarmuk. Palestine was now subdued, and Jerusalem, which was reputed a holy city by its ferocious conquerors, and was visited by the Caliph Omar. Here he directed Amrou to invade Egypt, which was rapidly overrun; and his other lieutenants to complete the conquest of Syria. His orders were punctually obeyed, and Aleppo, Antioch, Tyre, Cæsarea, and all the other cities and fortresses in the province, A. D.
were successively taken.

On the east the empire of the Arabs was rapidly extended. "They advanced," says the eloquent historian of the Decline and Fall of Rome, "to the banks and sources of the Euphrates and Tigris; the long-disputed

barrier of Rome and Persia was for ever confounded; the walls of Edessa and Amida, of Dara and Nisibis, which had resisted the arms and engines of Sapor or Nashirvan, were levelled in the dust." The fate of Persia was decided in the great battle of Cadesia. The victorious Arabs poured like a flood over the country, and acquired prodigious spoil; nor did they halt in their victorious career till they had reached the banks of the Oxus, and had added to their empire Herat, Merou, Balk, Samarcand, and other rich and trading cities in the East.

The short reign of Ali, from the year 655 to 661, was disturbed by domestic dissension and the rival claims of Moawiyah, the son of Abu Sophian, well known for his tardy and reluctant obedience to the sword, as was alleged, rather than to the doctrines of the prophet. The death of Ali by an assassin was the signal for new contests. Moawiyah reigned at Damascus, which was the new capital of the caliphs of the house of Ommiyah, and was succeeded by his son Yezid A. D. 680, whose title was disputed by the surviving family of Ali, Hozein and Abdallah Ebn Zobeir, his two sons. They fled from Medina to Mecca; and Hozein was proceeding to Cufa on assurances of aid from the inhabitants, when he was surrounded and barbarously murdered, with all his followers, by Obeidallah the governor. Abdallah, the sole representative of the house of Hashem, was now proclaimed caliph at Medina, from which city he expelled all the adherents and dependents of the house of Ommiyah, to the number of 8000. Yezid dispatched a large force to their aid, by which Medina was taken, after a vigorous defence, and abandoned to pillage. Mecca, besieged by the army of Yezid, was on the point of sharing the same fate, when intelligence was received of Yezid's death. His son, Moawiyah II., succeeded him, and, after a reign of six weeks, died without naming a successor. Serious commotions now ensued. Merwan, of the house of Ommiyah, was proclaimed caliph at Damascus, while Abdallah reigned at Mecca. The former was succeeded by his son Abdalmalac, during whose reign the contest for the throne was terminated by the death of Abdallah, who, in a desperate sally from Mecca, where he was besieged by the troops of the rival caliph, was overpowered and slain. By his death the sovereignty was firmly established in the line of the Ommiades, who reigned in Damascus above 70 years.

But the title of this dynasty not being founded on any clear principle of religion or of law, was never recognised by the great body of the Moslems. They regarded with veneration the lineal descendants of the prophet, who on their part still cherished the hope of reigning over the Moslem empire. Numerous partisans of the line of Abbas were dispersed throughout the provinces, and secret plots for their restoration were gradually matured into rebellion. The last caliph of the line of the Ommiades was met on the field by a powerful army commanded by Abdallah, the uncle of his rival; and after an irretrievable defeat he escaped to Mosul, and finally to Egypt, where he was defeated and slain, and the last remains of his party extinguished. Amid the ruin and massacre of his family by the conqueror, a royal youth, Abdalrahman, alone escaped, and making his way into Spain, laid the foundation of a new dynasty of the Ommiades, who reigned in Cordova with great splendour for 250 years, from the Atlantic to the Pyrenees. In Egypt and Africa the Fatimite caliphs, the progeny of Ali, were invested with royal authority; and the new line of the Abassides transferring the seat of government from Damascus to the banks of the Euphrates, laid the foundation of Bagdad, the seat of their empire, and of wealth, literature, and science, for 500 years.

In the course of these various revolutions and splendid conquests, Arabia, the original seat of the Mahometans, had dwindled into an inconsiderable province of their vast empire, and the rude inhabitant of the desert resumed his solitary independence, heedless alike of distant victories as of domestic changes. The Hedjaz, the mountainous district of Arabia, and the chief seat of its commerce and its towns, was governed by the lieutenants of the caliphs,[1] or sherifs as they are called, who are chosen from the tribe of the Koreish, and who have always acted as the resident sovereigns of the country. But their power was unknown in the desert, where the scheiks still continued to rule. In the disorders attending the decay of the Mahometan power, Arabia was occasionally invaded by hostile tribes; but it was chiefly the outskirts of the country that were scathed by the flame of war, which never penetrated to the interior. It appears from the incidental and scattered notices which we possess, that about the year 1173 Sultan Saladin subdued a king who reigned in Yemen, and who had revolted against the authority of the caliphs of the line of Abassides. Having reduced the country, he committed the government to two deputies, who afterwards claiming independent power, were in their turn reduced by the troops of Saladin. In 1517, when Selim I. conquered Egypt, and extinguished the last surviving representative of the second dynasty of the Abassides, the sherif of Mecca brought to him the keys of the city; and the Arabian tribes professed their allegiance, and gave hostages as a pledge of their fidelity. The country continued under subjection for 50 years, when Muttahir, sherif of the kingdom, impatient of the Turkish yoke, attacked and routed the army of Murad Pacha, and freed the country for a time from its oppressors. A powerful army, commanded by the governor of Egypt, was dispatched by Selim II. to Yemen; the Arabian force was defeated and dispersed, and the authority of the sultan was re-established in Yemen, and extended backwards to the highlands. The country, thus reduced, was governed as a Turkish province by pachas sent from Constantinople. But in the interior the independent princes and scheiks still retained their authority, and continued to harass the Turks, and to drive them back to the coasts. They were expelled from the province of Yemen about the middle of the 17th century; and since this period until the invasion of the country by Mohammed Ali they have only possessed a precarious and nominal authority in the towns of Djidda and Mecca.[2]

Wahabys.

The rise of the sect of the Wahabys, and the rapid extension of their dominion and doctrines, forms a most important epoch in the more recent history of Arabia. These sectaries were the reformers of religion in the East. They were zealous followers of Mahomet, who were scandalized by the departure of modern believers from the simplicity of the faith; by their worship at the tombs of saints; by the luxurious ostentation of their dress; their remiss attendance at public prayers; the immorality of their lives; the scandalous indecencies which they practised in the holy temple of Mecca; and

[1] "Depuis ce tems-là (de Mahomet) les Arabes de l'Iemen (Yemen), et de toutes autres provinces de l'Arabie, sont toujours demeurés sous l'obéissance des Khalifs, ou de Bagdet ou Egypte, tant que le Khalifat a durée." (Herbelot, *Bibliothèque Orientale*, Iaman.)

[2] De Guignes, *Histoire des Huns*, tome i. livre vii. Cantemir's *History of the Growth and Decay of the Othman Empire*; Niebuhr, *Description de l'Arabie*.

Arabia.

finally, in opposition to the strict prohibitions of the Koran, by their free use of tobacco and other intoxicating drugs.[1] Such were the chief articles of the new creed, which, in the same manner as the faith itself, was propagated by fire and sword. Its founder was Mohammed-Ebn-Abd-el Wahab, the son of a scheik in an obscure village, born in the year 1691, whose history and success for nearly a century seemed to presage the final triumph of his doctrines and his arms. It is remarkable that the only two great revolutions which have ever taken place in Arabia have had their origin in religion. It was in both cases for religion that the sword was ostensibly drawn. The subjection or extinction of infidel tribes was a step in the progress of the pious work; and these objects being accomplished, the original design, however spiritual in its nature, necessarily terminated in conquest and political dominion. The young apostle of the new faith was trained in the strict principles of Mahometanism. He was sent to finish his studies in the university of Bassora; and on his return to his native village, commencing reformer of religion and of manners, he was banished by the governor. He took refuge in Derayeh, the capital of Nedjed, where he was protected by the scheik Mohammed-Ebn-Saouhoud, a zealous disciple, from political views, as was insinuated, of the reformed faith. Here the new tenets were embraced by crowds of proselytes, eager to draw their swords in the cause of truth; and so well did the Wahaby chief Saoud profit by their new-born zeal, that before his death in 1765 he had extended his faith and his dominion over the whole province of Nedjed. His son Abd-el-Azyz enlarged by new conquests the power of the Wahabys. He subdued and rendered tributary the surrounding tribes, threatened the holy cities, and finally spread the terror of his arms over all the northern parts of Arabia, from Mecca and Medina to Damascus, Bagdad, and Bassora. Mohammed-Ebn-Abd-el Wahab, the founder of the Wahaby sect, died in 1787, at the advanced age of 95. But this event noway damped the zeal of his followers. Their expeditions were dreaded all along the banks of the Euphrates, and in the neighbourhood of Bassora, which they invaded every year, committing great excesses, and massacring the Arab settlers who were the subjects of the Bagdad government. In 1797 the pacha of Bagdad undertook an expedition against Derayeh, the capital of the Wahabys. He was repulsed by Saoud, the son of the reigning chief, who continued his inroads into the Turkish territories on the Euphrates. In 1801 he stormed the town of Imam Hosseyn, where, according to the intolerant maxims of the new sect, 5000 persons were massacred.

Ghaleb, the sherif of Mecca, was alarmed by the conquests of the Wahabys, and since the year 1792 had been vainly contending against their rising power. In 1801 the sectaries invaded his dominions in great force. In 1802 they stormed the town of Tayf, which they gave up to a general massacre, in which neither men, women, nor children were spared. In 1803 the holy city, notwithstanding the brave resistance of Sherif Ghaleb, surrendered at discretion to the victorious Wahabys. On entering it, the strictest discipline was preserved by Saoud the chief, and not the slightest excess was committed. The inhabitants were, however, compelled to a more punctual attendance at prayers; to conceal their silk dresses; all their finely ornamented Persian pipes were collected before Saoud's house, and there committed to the flames; and the sale of tobacco was forbidden. Mecca was afterwards given up to the government of Sherif Ghaleb, on the usual condition of his conversion to the Wahaby faith. This conquest was followed by the reduction of the neighbouring tribes, and in 1804 Medina surrendered to the Wahaby arms. Here they rigorously enforced the duty of public worship; the absent were punished; and a respectable woman, accused of smoking the Persian pipe, was placed upon a jack-ass, and paraded through the town with the pipe suspended round her neck. Saoud soon after visited Medina, and carried away from the tomb of Mahomet all the valuable articles, namely, jewels and pearls, and Cufic manuscripts of the Koran, which it contained; and ordered his troops, according to the approved maxims of his sect, who reprobate the worship of saints, to destroy the cupola over the tomb; but it was so strong that with all their efforts they could not deface this curious relic of antiquity.

The Hedjaz continued to enjoy tranquillity during the years 1806, 1807, and 1808, under the divided rule of the sherif of Mecca and of the Wahabys, the power of the former gradually declining, while Saoud was acknowledged as pontiff and king over the greater part of Arabia. The Wahaby hordes extended their inroads southward into the mountains of Yemen, whence they descended to the coasts and plundered the towns of Loheia and Hodeida. On the north they advanced into the Syrian desert, and alarmed the Bedouins in the vicinity of Aleppo, as well as the inhabitants of Damascus, who had begun to send away their valuable property to the mountains of Libanus. The Mesopotamian tribes near Bagdad were attacked and pillaged; and in 1810 Saoud, at the head of 20,000 troops, stormed the Persian town of Kerbeleh, putting all the male inhabitants to the sword.[2] The regular intercourse of the great pilgrim caravans from Syria, Egypt, Persia, and Yemen, had been interrupted since the year 1803, and the few scattered pilgrims that reached the holy cities from the north and west generally came across the Red Sea from Cosseir to Djidda.

The surrender of Mecca and Medina to the sectaries, and the interruption of the pilgrimages, excited the shame and indignation of all pious Mahometans. Mohammed Ali, who in 1804 was appointed pacha of Egypt, received instructions from the Porte to undertake the reconquest of the Holy Land. He accordingly determined on the invasion of Arabia, and prepared an expedition, which he committed to his son Tousoun Bey, and Ahmed Aga his treasurer. The infantry, amounting to 2000 troops, landed at Yembo from Suez in October 1811, and took the town after a slight resistance. In January 1812 Tousoun advanced against Medina; but he was assailed in the mountain passes, through which his route lay, by a powerful army of Wahabys, and utterly routed, with the loss of all his baggage and artillery. Being in the course of the summer largely reinforced from Egypt, he again advanced to Medina in November; and having sprung a mine and overthrown part of the wall, he carried the town by assault, massacring about 1000 of the garrison in the streets. The remainder, to the number of 1500, retired to the castle, which they afterwards surrendered on condition of receiving a safe conduct for themselves and baggage; in defiance of which they were, on quitting the town, treacherously massacred by the Turkish troops. Sherif Ghaleb, intimidated by the capture of Medina, now intimated his desire of surrendering the holy city to the Turkish commander. Mecca, with Djidda, its port, was accordingly taken possession of in January 1813 without any opposition; and in a fortnight the town of Tayf, which had been held by the Wahabys for sixteen years,

[1] Felix Mengin, *Histoire de l'Egypte sous le Gouvernement de Mohammed Ali*, tome i. p. 379.

[2] *Ibid.* tome i. p. 360.

surrendered after a feeble resistance.[1] In 1813 Mohammed Ali landed at Djidda; and on his arrival at Mecca, suspecting the hostile intrigues of Sherif Ghaleb with the Arab tribes, he caused him to be arrested and sent under a guard to Egypt. He was succeeded in the government of Mecca by Yahya, also of the sherif family, the humble tool of Mohammed Ali. In the mean time the Turkish army, weakened by its losses, remained at Mecca and Tayf; and, with the exception of an unsuccessful expedition against Toraba, the chief town of the southern Wahabys, and the capture of Gonfode, a port seven days' journey south of Djidda, which was soon after recaptured, no enterprise of any importance had been undertaken since the surrender of Mecca and Tayf. But Mohammed Ali was not idle. He employed the time in reinforcing his wasted army, in collecting magazines and stores, in purchasing camels, and in strengthening his influence among the Arab chiefs, many of whom he succeeded in detaching from the Wahabys by the influence of presents and money.

Saoud, the successful chief of the Wahabys, died at Nedjed in 1814, and his son Abdallah, who succeeded him, though he was brave, was inferior to his father in all the qualities of a political chief. The pacha having completed his preparations, now resolved to strike a decisive blow. In January 1815 he began his march southward in the direction of Toraba. The Wahabys, to the number of 25,000, occupied a strong position on the mountains near Byssel, from which, after some unsuccessful attempts to dislodge them, he contrived, by a feigned retreat, to draw them into the plain. Here their disorderly host was borne down by the steady attack of the pacha's disciplined force, and flying in confusion, they were cut down without mercy by the Turkish cavalry. A reward of six dollars being offered for the head of every Wahaby, 5000 of these bloody trophies were in a few hours piled up before the pacha's tent. Of 300 prisoners who were taken, 50 were, according to the cruel maxims of the East, impaled alive before the gates of Mecca, and the rest at other parts. Mohammed Ali hastened to profit by his victory. He arrived in four days before Toraba, which capitulated; and advancing southward, he encountered the wreck of the Wahaby army in the mountains near the town of Beishe. Here, after a brave resistance under Tamy, their chief, who was seen riding in front, animating the troops by his war songs, they gave way before the Turkish artillery. Tamy, who was betrayed into the hands of his enemies by an Arab chief, and by his gallant bearing gained the esteem of the whole army, was sent to Constantinople, where he was instantly beheaded. Another chief, Bakhoudj, was tortured to death in presence of the pacha. The Turkish army continued the pursuit of the Wahabys, and subdued most of the southern tribes. Mohammed Ali was intent on carrying the war into Yemen, whose rich cities he hoped to plunder; but the wasted state of the army forced him to an immediate retreat. He himself accordingly proceeded to Gonfode on the seashore, and arrived at Mecca on the 21st of March, after an absence of 15 days. Of his army, consisting of 4000 Turks, he brought back only 1500; and of 10,000 camels, only 300 survived the fatigues of the campaign.

The war against the northern Wahabys was prosecuted with vigour by Tousoun Pacha, who had advanced eastward from Medina to Khabara, about 300 miles into the interior of the country. Abdallah had fixed his head quarters at Shenana, only five hours' march from the Turkish army. Tousoun was here seriously embarrassed by the want of supplies. His treasurer Ibrahim Aga,[2] with a detachment, had been some time before surrounded on the road and cut to pieces, after a gallant resistance, and his remaining troops were averse to a battle. From these difficulties he was extricated by a peace, which Abdallah weakly concluded with him, and by which he agreed to renounce the possession of the holy cities, to be ranked among the faithful subjects of the sultan, to pray for him in the mosques, and to submit to his authority as his sovereign. But this treaty, however disgraceful to the Wahabys, was far from satisfying the views of Mohammed Ali, who, with his usual contempt of all engagements, refused to ratify it; and conscious of his strength, would enter into no overtures from Abdallah, however humble, having determined either to reduce or to exterminate the rebellious sectaries of Arabia of which he was the head. Both parties accordingly prepared for war. In September 1815 Ibrahim Pacha, son of Mohammed Ali, landed at Yembo with 2000 Turkish troops, besides 2000 peasants pressed into his service at Siout on the Nile, amid the outcries of their wives and children. He had also a corps of 500 Moggrebins from Barbary. Having spent some time at Medina in reducing the surrounding tribes, and visiting the holy sepulchre, he directed all the troops which could be spared from the different garrisons to march on Hanakye or Henakyeh, about 100 miles eastward of Medina, where, early in December, his whole force was concentrated. Here he remained till the end of April 1817; and though his troops suffered severely under fever and dysentery, the diseases of the climate, he succeeded, by several bold and well-concerted expeditions, in impressing on the Arab tribes the terror of his arms. He extended his alliances among them, and by his policy as well as by his arms he silently prepared the ruin of the Wahaby state. In the conduct of the war Ibrahim combined, with the cruelty of a Turkish conqueror, undaunted courage and skill, a rare perseverance under difficulties, and a fertility of resource which seldom failed him. The discipline of his troops secured his superiority in the field; and the Wahaby host, avoiding the risk of a battle, relied on their fortresses, the nakedness of the land, and the noxious climate. The issue of the war was thus reduced to a mere arithmetical question of the number of men that would be required to carry it on. These being provided, the conquest of the country was certain, and Mohammed Ali was too well versed in war not to see the advantages which he possessed, and too deeply interested to grudge the necessary supplies. He was willing to pay the fair price of his success. The army of Ibrahim, notwithstanding its losses, was accordingly maintained at its full complement by recruits from Egypt; and he now hastened to complete the conquest of the country by reducing its strongholds, and especially Derayeh, its capital. He had gone to the village of Maouyeh, where he was joined by a powerful chief; and having assembled all his forces, consisting of 4000 infantry and 1200 horse, besides his Arab auxiliaries, he advanced in July to the fortress of Rass. In three several assaults, conducted with desperate valour, but without skill, the assailants were overwhelmed, and finally repulsed with severe loss, by the well-directed fire of the

[1] Burckhardt's *Notes on the Bedouins and Wahabys*, p. 356–7. Mengin, *Histoire de l'Egypte*.

[2] Ibrahim Aga was a native of Edinburgh, named Thomas Keith, a private in the 72d regiment of highlanders, and taken prisoner the last expedition of the English to Egypt. He became a mussulman, and on account of his valour was promoted to the high fice of treasurer by Tousoun Pacha.

Arabia || Arabist.

garrison; and Ibrahim, after vainly contending for three months and 17 days against the obstinate valour of the inhabitants, and incurring a loss of 3400 men, was forced to raise the siege of an ill-fortified place, which, with the aid of engineers, he might have reduced in two days. But this was the only disaster which befell the Turkish arms. The sequel of the campaign was one continued course of conquest. Khabra, Aneyzey and its castle, and Banneydeh, successively fell after a slight resistance. At the latter place the Turkish army remained for two months. Having received large reinforcements, it commenced its march, accompanied by a train of 10,000 camels and other beasts of burden, across frightful deserts of sand, and in January 1818 encamped at Chakra, which was taken after a siege of seven days. The town of Dorama was stormed after a brave resistance, and abandoned to pillage and the sword; and on the 22d of March Ibrahim directed his victorious march to Derayeh, the capital, and last stronghold of the Wahaby state. This place, which consists of five small towns, each surrounded with a wall protected by bastions at small distances, was now closely besieged by the Turkish army, which, including infantry and cavalry, amounted to 5500 troops. The siege was long and obstinate, but the Turkish troops still maintained their superiority. The different divisions of the town were successively stormed; and the unfortunate Abdallah, thus driven to his last retreat, was reduced to ask a suspension of arms and a conference. His interview with Ibrahim presented a touching spectacle of fallen dignity. He demanded peace: the conqueror granted his request, but added that he was not authorized to leave him at Derayeh,—the positive order of his father was that he should repair to Egypt. Abdallah, after 24 hours of deliberation, intimated his assent to the proposed terms, and only conditioned for his life. Ibrahim would not answer for the decision either of his father or the sultan, farther than that he thought them both too generous to take his life. Abdallah, having bidden a last adieu to his afflicted family, repaired to the tent of Ibrahim, from which he set out on his journey across the desert, and arrived at Cairo. He was sent to Constantinople, where, notwithstanding the intercession of Mohammed Ali, he was beheaded, along with his companions in misfortune, in the square of St Sophia, after being exhibited in every part of the city for three days. With the death of Abdallah terminated the dominion of the Wahabys, which, under a succession of vigorous and politic princes, had in the course of a century been extended over the whole peninsula of Arabia. But their empire, loosely held together by the tenure of recent conquest, was overthrown by the first attack to which it was exposed. The chiefs who yielded to the terror of the Wahaby arms deserted on the first appearance of a hostile army; others were seduced by the influence of gold, which was liberally distributed; and domestic dissension coming in aid of foreign war, dissolved the union of the tribes, and completed the ruin of the country. According to M. Mengin, whose information is undoubted,[1] Arabia had ample means of defence, in the difficulties of the country, and in the numbers, intrepidity, and discipline of its troops; and, with an able leader, he expresses his strong and apparently just conviction, that the Turkish army, in place of conquering the country, would have perished in its burning deserts.

The ruin of the Wahabys is deeply to be regretted, as it may throw back for several centuries the civilization of Arabia. The Wahaby princes reformed the morals as well as the religion of their country. Under the reign of Saoud the administration of justice was rigid and impartial. The crimes of rapine, thieving, and murder, so common among the Arab tribes, were severely punished; an exact police was established throughout the country; and caravans and travellers were seen journeying on all the roads in perfect security. The Turkish conquests will restore the primitive barbarity of the Arabian manners, and anarchy and crime will resume their wonted sway. But Arabia contains within itself the seeds of independence. The distance of Nedjed from Cairo, and the expense and difficulty of sending supplies through the interior deserts, will render it extremely difficult to maintain a Turkish force in the heart of the country; while the religious principles of the tribes, their warlike character and love of freedom, animating them to new efforts, may yet enable them to triumph over the foreign tyranny which oppresses them, and to re-establish their freedom on a new and a more secure basis. (E.)

ARABICI, a sect who sprung up in Arabia about the year 207, whose distinguishing tenet was, that the soul died with the body, and also arose again with it. Eusebius (lib. vi. c. 38) relates that a council was called to stop the progress of this rising sect; and that Origen assisted at it, and convinced them so thoroughly of their error that they abjured it.

ARABISM, Arabismus, an idiom or manner of speaking peculiar to the Arabs or the Arabic language.

ARABIST, a person curious of and skilled in the learning and language of the Arabians: such were Erpenius and Golius. The surgeons of the 13th century are called *Arabists* by Severinus.

ARACAN. See Arracan.

ARACHNE, in fabulous history, a young maid of Lydia, said to have been the inventress of spinning. She is fabled to have been so skilful in this art as to challenge Minerva at it, who tore her work, and struck her; which disgrace driving her to despair, she hanged herself. Minerva, from compassion, brought her to life, and transformed her into a spider, which still employs itself in spinning.

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[1] M. Felix Mengin landed in Egypt with the French expedition under Buonaparte. He remained in Cairo for 20 years after the country was evacuated by his countrymen, where he collected much valuable information respecting the internal administration of Egypt and the Wahabys. His account of this Mahometan sect is derived from the grandson of Ebn-Abdul-Wahab, its founder.

ARACHNIDES,

Arachnides.

From αραχνη, a *spider*, and ειδος, *resemblance*, a class of invertebrated animals, formerly regarded as true insects, and as such classed by Linnæus in his order Aptera, under the generic names of *Phalangium*, *Aranea*, *Acarus*, and *Scorpio*. The Arachnides were first formed into a distinct class by M. Lamarck, whose arrangement of the Linnæan Aptera is admitted by Latreille to approach the most nearly to the natural order.

The third primary division in the system of Cuvier, that of the articulated animals (*animalia articulata*), contains four great classes, viz. Annelides, Crustacea, Arachnides, and Insecta. We have already stated our intention (see Animal Kingdom) to treat of the first of these classes under the title of Helminthology, of the last under Entomology, and of the two intermediate classes in the order of their alphabetical occurrence. We shall therefore now proceed with the history and classification of Arachnides.

The naturalists who preceded Lamarck appear to have confounded this class either with the true Insecta, or with the crustaceous tribes, such as crabs and lobsters. It was in the course of his public lectures (in 1800) that the last-named observer instituted for their reception a separate class, under the title which they now bear.

Cuvier, in one of his earliest works (*Tableau Elémentaire de l'Hist. Nat. des Animaux*, 1798), continued, with his contemporaries, to class the Arachnides with insects, of which he regarded them as forming the third principal division, preceded only by the Crustacea and Myriapoda; thus far departing from and improving the old Linnæan system, by assigning them a higher place in his general arrangement, but not yet admitting them to the honour of a separate class.

Lamarck published the first edition of his *Système des Animaux sans Vertèbres* in the year 1801, and he there explains the reasons which induced him to form the separation previously advocated in his lectures.

M. Latreille did not admit the *classic* separation of the Arachnides, either in his *Histoire Naturelle de Crustacés et des Insectes* (1802–5), or in his later work, the *Genera Crustaceorum et Insectorum* (1806–7), but merely placed them at the head of the class of insects. In a subsequent volume, however (*Considérations Générales sur l'Ordre Naturel des Crustacés*, &c. 1810), he practically admits the propriety of M. Lamarck's views; and in it we find the Arachnides forming a separate class, and constituted of the same materials as those used by his predecessor. In that portion of Baron Cuvier's *Règne Animal* (vol. iii. 1817) of which M. Latreille is the author, we find the same arrangement followed, with this exception, that in the last-named work the Myriapoda and Chelopoda are removed from the Arachnides and placed at the head of the class Insecta—a modification likewise adhered to both in the *Familles Naturelles du Règne Animal* (1825), and in the recent edition of the *Règne Animal* itself (1829), which contains the latest view of M. Latreille. By these, in as far as concerns our general principles of arrangement, we shall be chiefly guided in the course of this article; but we conceive it due to M. Lamarck to present our readers, in the first place, with a short statement of his opinions.[1]

He defines the Arachnides as follows: Oviparous animals, at all times provided with articulated legs,—not subject to metamorphoses, nor ever acquiring new kinds of organs. Respiration tracheal or branchial: stigmatiform openings for the entrance of the air. A rudimentary heart and circulation in the greater proportion of species. Copulationes plures per vitam in plurimis.[2]

It is known that no vertebrated animal provided with feet has ever more than four; and that among such as are invertebrated, those which in a state of complete development are provided with feet, have never less than six. Amongst invertebrated animals, insects have essentially the smallest number of feet; for the various orders and families of that class, when arrived at their final development, have never more than six. They are hence called *hexapods* by some modern writers. It is otherwise, however, with the Crustacea and Arachnides, the greater proportion of which have more than six feet. Certain species, in their earliest state, have no more than that number; but their other feet appear as they advance in age. A few are hexapod, or six-footed, during the entire term of their existence; but in addition to those characters which determine the class to which they belong, various other relations connect them with their congeners, and show that they are not genuine insects.

Among those articulated animals which possess no system of circulation, insects alone undergo genuine metamorphoses; and none of the Arachnides are subject to such changes. Now, as all Arachnides are essentially distinct from the Crustacea, and as they differ from insects in the important characteristic just mentioned, it follows, according to M. Lamarck, that they constitute an assemblage of beings which ought not to be held in separation, however diversified they may be in various points of their organization.

The most remarkable circumstances in the structure of Arachnides are the following: That while many of these creatures are obviously provided with a circulating system, others present no vestige of that system; that the former breathe by means of branchial cells, while the latter respire through tracheæ; and that certain tribes are provided with antennæ, and others are entirely destitute of any such organs. These apparent non-conformities of structure result from this, that throughout the extended course of their class, the organization of the Arachnides undergoes rapid and remarkable changes; and if in the course of our observations we were to attend not only to the differences of external or internal parts, but to the progress of nature in the order of her productions, we would sooner perceive the propriety of that succession or change of organization even among animals really allied to each other by the great majority of their relations; and it would not have been deemed necessary to remove to another class such of the Arachnides as were antennated, because it would have been then more clearly perceived how incompatible was such a change with the assignment of their natural and appropriate place in the system.

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[1] See the *Histoire Naturelle des Animaux sans Vertèbres*, 7 vols. 8vo. Paris, 1815–22.

[2] "Animalia ovipara, pedibus articulatis in omni tempore instructa, ad metamorphoses non subjecta, nec nova partium genera acquirentia. Respiratio trachealis aut branchialis: orificiis pro aeris intromissione stigmatiformibus. Cor circulatioque in pluribus inchoatis. Copulationes," &c. *ut supra*.

Arachnides.

The class of Arachnides, as established by Lamarck in his *Cours*, contained five or six small families, which, though each possessed of particular characters of distinction, it would have been difficult to separate from their common frame-work, without considerable inconvenience to whatever other class one or more of such families might have been removed. If, for example, the antennated Arachnides should be classed among insects, we then destroy the most simple and satisfactory definition which can be given of the last-named class, while we are forced to assign to the animals with which we unite them a position in the general series unsuitable to their real nature and attributes. If we transport the tracheal Arachnides to the class Insecta, in order to enable us to define the latter class by the exclusive character of respiring by tracheæ, then insects can no longer be said to be uniformly distinguished by the possession of antennæ, and the genus Phalangium, &c. would be separated from the class which contains the spiders. For these reasons Lamarck is of opinion that the division which contains his Arachnides, whether antennated or non-antennated, ought to be preserved in its integrity, if we wish to avoid the impropriety of associating with insects other forms of animal life which nature has distinguished by different characters.[1]

A class may be constituted of natural materials, and contained within suitable limits, and nevertheless present among its various families animals of very different forms and construction. During every period of its existence, a butterfly presents an aspect very dissimilar to that of a scarabæus, yet both belong to the true Insecta. When strong general affinities (*analogies d'ensemble*) prevail, those special diversities of structure which are occasionally observable are insufficient to authorize a separation of classes. The genera Aranea, Phalangium, and Galeodes, are very nearly related to each other, although the first respire by obvious branchial cells, while the others enjoy a tracheal respiration.

The non-antennated Arachnides are in general provided with eight feet; and the Acarides and Pycnogonides conduct naturally to the Phalangides, such as the genus phalangium and others. Now, if these Acarides belong essentially to the Arachnides, can the parasitical genera, such as Pediculus and Ricinus, which lead towards them so evidently, be regarded as belonging to another class? The transition is so gradual and prepared, that the Acarides, provided for the most part with eight feet, like the other non-antennated Arachnides, yet present us with many genera (such as Astoma, Leptis, Caris) which have never more than six. Lamarck maintains the necessity of preserving the class Arachnides according to the limits which he has himself assigned to it, because its being so preserved relieves the class of insects from species with which that class has little or no connection. Without citing the impossibility of assigning a suitable position among insects to tribes like the Parasites, the Thysanoura, and the Myriapoda, the strongest objection to the reunion of these animals with insects is, that it will alter the general and truly natural characters assigned to the latter, viz. that of presenting, after exclusion from the egg, a particular state of *larva*, singularly varied according to the different orders in the forms and parts of the animal, and that of finally exhibiting an *imago* or perfect state very different from the larva, and distinguished by six articulated legs, two reticulated eyes, and a pair of antennæ.

Arachnides, on the contrary, although in many instances antennated, and, like all other living beings, undergoing successive developments of parts from the period of their birth, yet offer not the condition of a larva distinct from that of the perfect state: they preserve, not of course the dimensions, but the form and proportions of the parts with which they were originally produced; and if a few of them acquire additional parts in the course of their development, these are not of a new kind, but merely supernumerary to such as previously existed; for example, a pair of feet, or another segment to the abdomen. But this kind of development is different from that called metamorphosis in insects. All of these acquire either a new form, or parts of structure of a different kind from those which they possessed when first produced from the egg; and their state of larva, manifestly distinct from that of the perfect insect, is never equivocal.

Thus the Arachnides of Lamarck, distinguished in a general point of view from true insects by the want of metamorphoses, yet breathing in air, are remarkable for the singular gradations which their organization presents us when we compare the different families with each other. In fact, these animals exhibit, in their totality, different groups, which offer among themselves such great dissimilarities of organization, as might almost furnish the materials of as many classes; but such a proceeding would injure the simplicity of systematic arrangement, and would be unsuitable, in as far as these great divisions might still be connected together by characters of general application, the same, in truth, as those by which the class of Arachnides is itself distinguished.

Although certain Arachnides possess organs adapted to a circulating system, they do not on that account belong to the crustaceous class. They are chiefly distinguished from that class by their respiratory organs, which, whether tracheal or branchial, are always placed in the interior of the body, whilst in the Crustacea they are external. In the former, also, the opening which admits the fluid to be respired is stigmatiform; but it is not so in the latter.

Even the structure of the eyes affords an index to the Arachnides. All true insects have two eyes, with plane facettes, presenting the appearance of a very delicate network; but in the Arachnides the eyes are smooth, whether isolated, as among the greater number, or grouped as in spiders, and form a small mass, of which the surface is granular or sub-granular, and not in facettes. Arachnides form a class superior to insects, because many of them are more highly organized, and all of them are more nearly allied to the Crustacea than genuine insects. It does not follow from this that all the individuals of that class are superior to the most perfect insects, or that they have derived their existence, according to the French phraseology, by transition from these last-named creatures, or by an advance or progression in the scale of organization. For in the progress of animal life from the lower to the higher groups, the Arachnides appear to commence almost at the same epoch as the genuine insects, and present a dichotomous or double ramification, corresponding in its level with that which bears the entire class of insects. About that same point of the animal kingdom there seems in fact to be three distinct streams or courses of life, immediately succeeding the Epizoaria, viz. that of the apterous insects (*Pulex*), which leads successively to all the other forms of insect life; that of the antennated parasitical Arachnides (*Pediculus* and *Ricinus*), which leads to the Acarides and other non-antennated Arachnides; and that of the wandering (*vagabundæ*) antennated Arachnides (Thysanoura and Myriapoda), from which the crustaceous tribes may be said to spring.[2]

[1] *Animaux sans Vertèbres*, tome v. p. 6.

[2] *Ibid.* tome v. p. 10.

Thus, of those great divisions which appear to derive their origin almost from the same point in the scale, the first is formed of an enormous series of animated beings, characterized by the strongly contrasted aspects of larva and perfect insect; and the others are true Arachnides, and consequently present no such marked distinction between the conditions of the young and old. In the most perfect of the arachnidean class, such as spiders and scorpions, Cuvier has demonstrated a muscular and dorsal heart, subject to sensible systole and diastole; and on the abdomen he discovered several stigmatic openings (from two to eight), which lead to an equal number of particular purse-shaped cavities, each of which contained a great many small and very delicate laminæ or plates. These isolated cavities, and the plates with which they are filled, are without doubt the respiratory organs of these Arachnides. Cuvier regards them in the light of lungs; while Lamarck himself is inclined to view them rather as branchial cavities analogous to those observable in the leech and earth-worm—the property of branchia being, in the first place, the power of becoming habituated to the respiration of air (water being their usual medium), whilst the true lung respires air alone; and, in the second place (and this character applies of course *a fortiori* to lungs also), never to exist except in animals which are possessed of a circulating system.[1]

Finally, from the dorsal heart already mentioned two large vessels derive their origin, and are then ramified over the membrane of the respiratory cavities. Cuvier regards these vessels as pulmonary, the one acting as an artery, the other as a vein—and other vessels spring from the same dorsal trunk, and distribute themselves to various parts of the body. In these animals there is even a liver, composed of four pair of glandular clusters, which discharge their fluid at four different points of the intestine.

It is among the Arachnides that we find the first establishment of organs for the circulation of the animal fluids; and in the same class we perceive, as it were, the termination of tracheal respiration by ramified tracheæ, with a view to the substitution of the branchial system, which, though in itself admitting of considerable variation, is always characterized by its more local restriction. Among the Arachnides also we find the commencement of the principal of the conglomerated glands.

The respiratory sacks, which Cuvier pointed out in the spiders and scorpions, were also detected by M. Latreille in the genus Phryna, in such a manner as to connect, by that dominating feature in their structure, the Arachnides *pedipalpes* and the Arachnides *fileuses* of that author. Although among the Phalangides the respiratory sacks have not yet become perceptible, yet the aeriferous tracheæ have changed their character, and no longer consist of a double cord with a series of plexus, but are merely branched or ramified. The same order prevails among the Acarides, and results mainly from the reduced number and altered position of the stigmata. Among the antennated Arachnides, in which the stigmata are more numerous, and in general lateral, the tracheal cords, like those of insects, have as many plexus as stigmata; and such Arachnides, in fact, approach the most nearly to the class of insects. Thus tracheal respiration changes by degrees its nature and mode of action, as the stigmata undergo an alteration in regard to their number and position; and, becoming more and more reduced and restricted, it prepares the way, as it were, for branchial respiration, which only shows itself effectively along with the establishment of a circulating system. It results from these considerations that, in spite of the difference of organization observable in different families of Arachnides, these families are nevertheless related and united by natural affinities, which it is impossible to mistake, and would be improper to separate, and which appear to place them at an almost equal distance from Insects and Crustacea. In their aspect, however, they in general resemble somewhat more nearly the latter class. For example, the cancerides or crabs represent in some respects, by their short bodies, and heads confounded with the thorax, the usual form of spiders; while the cray-fish and Thalassinæ (*Cancer anomalus*, Leach) recall the figure of the scorpion.

The greater proportion of Arachnides dwell on the land, a few inhabit the waters, and a certain number are parasitical on the bodies of other animals, of which they suck the juices. In general they are carnivorous, and live on blood, or at least on animal substances; a very limited number existing on vegetable matter. Many are furnished with mandibles, which perform the functions of a trunk or sucker; and others are provided with an isolated or separate trunk, frequently accompanied both by mandibles and palpi. They are for the most part solitary animals, of gloomy habits, and forbidding aspect; they court concealment, and avoid exposure to strong light. The bite of many species is dangerous, in consequence of a poisonous or irritating fluid frequently instilled into the wound. The offensive organ in the scorpionides is placed at the extremity of the abdomen.

The following is a tabular view of M. Lamarck's system of arrangement.

General Division of Arachnides.

Order I.—*Antennated tracheal Arachnides.* Head furnished with two antennæ. Respiration effected by means of double-corded plexiform tracheæ.

Section I.—*Crustaceous Arachnides.* Two composite eyes, of which the surface is granular or sub-granular. They are sometimes called wandering Arachnides, to distinguish them from such as are fixed or parasitical. They are frequently of a scaly structure, and provided with mandibles fitted for incision and division. This section consists of two families, viz. *Thysanoura* and *Myriapoda.* The following are the genera of *Thysanoura:* Smynthurus, Podura, Machilis, Lepisma. Those of *Myriapoda* are, Scutigera, Lithobius, Scolopendra, Polyxenus, Julus, Glomeris.

Section II.—*Acarideous Arachnides.* Two or four smooth eyes. These animals are parasitical, and provided either with a retractile sucker or with two mandibles hooked for the purpose of adhesion. Their bodies are never scaly. The genera are Pediculus and Ricinus.

Order II.—*Non-antennated tracheal Arachnides.* No antennæ. Tracheæ for respiration branched, but not ganglionized. Two or four smooth eyes.

Section I.—Body either without apparent division, the head, thorax, and abdomen, being united in one mass, or composed of two divisions. This section is composed of two families, viz. *Acarides* and *Phalangides.* The former contains the following genera: Astoma, Leptus, Caris, Ixodes, Argas, Uropoda, Smaris, Bdella, Acarus, Cheyletus, Gamasus, Oribata, Erythræus, Trombidium, Hydrachna, Elais, Limnochares. The

[1] *Analyse des Travaux des Sciences de l'Institut pendant l'année* 1810.

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genera of *Phalangides* are these—Trogulus, Siro, Phalangium.

SECTION II.—Body divided into three or four distinct segments. This section is likewise composed of two families, *Pycnogonides* and *Pseudo-scorpiones*. Of the first family the genera are, Nymphum, Phoxichilus, Pycnogonum; of the second, Galeodes, Chelifer.

ORDER III.—*Non-antennated branchial Arachnides.* No antennæ. Branchial cells or pouches for respiration. From six to eight smooth eyes.

SECTION I.—*Pedipalpi* or *Scorpionidæ*. Palpi very large, in the form of projecting arms, terminated by claws or pincers. Abdomen distinctly ringed, and not furnished with a spinning apparatus. Genera—Scorpio, Thelyphonus, Phrynus.

SECTION II.—*Araneides* or *Spinning Arachnides*. Palpi simple, in the form of small feet; those of the male bearing the sexual organs. Mandibles terminated by a movable crotchet. Abdomen without rings, and furnished at its termination with a web-making apparatus, consisting of from four to six spinners. Genera—Aranea, divided into numerous tribes or sub-genera; Atypus, Mygale, Avicularia.

In his *Considérations Générales*, M. Latreille founds the orders of the class Arachnides on two principal points as the first basis. These animals are either masticators or suckers. The jaws of the former are simple, and fitted for cutting and triturating the substances on which they feed; those of the latter, when they exist at all, serve only to seize their prey, and are terminated by a movable piece, either solitary and hooked, like a claw or crotchet, or accompanied by a fixed projection like a small finger. In the latter case the mandibles have the appearance of a pair of pincers. The Arachnides of this division compress with their pincers the small animals on which they prey, and so force the alimentary juices to pass by degrees into the œsophagus. The body of their prey having undergone this operation, is thrown aside. In spiders the claw of the mandible seems to execute an additional function. It distils a poisonous liquid, analogous in its nature to that which exudes from the mouth of the scolopendra, and the tail or sting of the scorpion. Moreover, all the masticating Arachnides are furnished with antennæ, while the suctorial tribes, with the exception of two genera, Ricinus and Pulex, are unprovided with these organs. Thus the primary divisions of this class by Latreille nearly correspond to Lamarck's two orders, the *Antennistes* and *Palpistes*.

M. Latreille then subdivides the masticating Arachnides into three orders—*Tetracera*, *Myriapoda*, and *Thysanoura*. The last alone present a thorax distinct from the abdomen, and have no more than six feet. In the two first-named orders the organs of movement amount at least to the number of fourteen, disposed along the sides of the body, each segment of which, with the exception at most of the last three, carry one or two pair. The Tetracera (genus *Oniscus* of Linnæus) are distinguished by four antennæ; there are only two in the Myriapoda. The Tetracera have besides several jaws, and are furnished with plates or foliaceous appendages on the inferior surface of the posterior extremity of their bodies. The number of their feet is invariably fourteen. They are related in several particulars to the Crustacea. De Geer observed, that in Assellus and Idotea there is a kind of membranous cavity, frequently filled with air, beneath the plates of the tail; and similar parts are observable in the true crustaceous Squillæ of Fabricius. In Oniscus the air penetrates the body by openings, which are covered by the first folds of the tail. The other Tetracera probably receive it in a similar manner: at all events they are not provided with distinct external stigmata, like the Arachnides of the succeeding orders. We still find in this first division species which inhabit the sea; but as soon as we enter the order Acera (scorpions, spiders, &c.) we find none occurring in that element.

The structure of suctorial Arachnides is reducible to three principal forms or combinations of organs; 1*st*, Those possessed of antennæ, and of which the head is distinct from the thorax—*Parasita*; 2*d*, Those which are unprovided with antennæ, each segment of the body furnished with a pair of legs, and the head distinct—*Pycnogonides*; 3*d*, Those which are unprovided with antennæ, but of which the head and thorax are confounded as it were in a single segment, which alone is provided with feet—*Acera*. This last-mentioned order, according to Latreille, would form the first, if the organs of the mouth alone were considered, as these are more complicated than in any other suctorial Arachnides. The Acera have two palpigerous maxillæ, and frequently a lip, with two strong mandibles. The generality of the Pycnogonides have also mandibles, which have been taken for palpi, and true palpi, which have been erroneously regarded as antennæ; but their mouth consists of a tunnel or syphon of a single piece. It is still more simple in the Parasites, being nothing more than a very short projection, containing a small sucker, or a cavity of which the sides are dilatable, and accompanied by two crotchets.

In regard to the *families* of the Arachnides, the Tetracera offer two principal groups. Some dwell in salt or fresh water, are usually fixed upon other animals, of which they suck the blood, and have, with the exception of the genus Bobyra, four very obvious and distinct antennæ. They constitute the first family, that of *Asellota*. Others are more terrestrial than aquatic. They wander from place to place, love obscure and sombre situations, and live upon putrid substances; their two intermediate antennæ are but slightly developed. They form the second family, called *Oniscides*. According to Latreille, the structure of the mouth in Scolopendra is so different from that of Julus, that it is difficult to conceive the motive which influenced Fabricius to unite these Arachnides into a single order, that of *Mitosata*. In Julus, the maxillæ and the lip are soldered together, forming one transverse plate, without distinct palpi, or their place supplied by tubercles. The Scolopendræ have their maxillæ separated, four projecting palpi, and the labia in the form of hooks, subservient to the same uses as the mandibles of spiders. These considerations, and the figure of the antennæ, have required the establishment of two families, which compose Latreille's order Myriapoda, viz. *Chilognatha* and *Syngnatha*. Proceeding upon the same principles, he divides the order Thysanoura likewise into two families, the *Lepismenæ* and the *Podurellæ*. The next orders, Parasita and Pycnogonides, contain few genera, and do not admit of subdivision into families. The last order, Acera, is composed of eight families, viz. Scorpionides, Pedipalpi, Aranides, Phalangita, Acaridiæ, Riciniæ, Hydrachnellæ, and Microphthira.

Before commencing our systematic exposition of this class, we shall lay before our readers the sentiments of Mr Kirby. "I must next say something on the orders of the Arachnida. Every one at first sight sees that *spiders* and *scorpions* are separated by characters so strongly marked, that they look rather like animals belonging to different classes, than to the same. These form the two primary orders of the *Arachnida*, and they appear to be connected by two secondary or osculant ones,—on the one side by *Galeodes*, and on the other by *Thelyphonus* and *Phrynus*. This class, although there is an appearance of

eight legs, is, strictly speaking, of a *Hexapod* type; for the anterior pair, ordinarily regarded as legs, and performing their function, are really the analogues of the maxillary palpi of perfect insects. This will be evident to you if you examine any species of *Galeodes*. These animals, if we look at them cursorily, we should regard as decapods; but when we trace the two anterior pairs of apparent legs to their insertion, we find that both proceed from the *head*, which in that genus is distinct from the trunk; while the three last pairs, which alone are furnished with claws, are planted, as legs usually are, in the latter part. The first pair represent the ordinary palpi of *Arachnida*, are analogous to the labial ones of hexapods, and, as likewise in Phrynus and Thelyphonus, are more robust than what are usually taken for the first pair of legs; but they differ in being considerably longer, and, instead of terminating in a *chela*, are furnished with a retractile sucker.[1] The second pair are more slender and shorter than the first. They correspond precisely with what are deemed the first pair of legs of *Octopods* and *Arachnida*, and are clearly analogous to the maxillary palpi of insects. Whether the base of the first pair of these palpi is in any respect analogous to the labium of insects (as that of the second seems to be to their maxillæ), I am not prepared to assert; it will therefore be most advisable to name these palpi *anterior* and *posterior*; but as they evidently proceed from the head in Galeodes, and in that genus are clearly analogous to those of the Phrynidea (which in their turn as clearly represent those of the Aranidea), it follows, that in all they are organs of the part representing the head, and therefore not in a *primary* sense *legs*, although in a *secondary*, as M. Savigny[2] has proved, they may be so called."[3]

The following are the secondary groups of the class Arachnides, according to Mr Kirby's exposition, in the work last quoted.

1. Aranidea.—M'Leay. (*Aranea*, L., *Araneidæ*, Lat.) The Aranidea or spiders seem resolvable into two sub-orders—the *Sedentaries* and the *Wanderers*; thus forming, perhaps, what Mr M'Leay would denominate the normal groups of a circle of *Arachnida*.

Def.—*Mandibles* armed with a perforated claw. *Head* and *trunk* coalite. *Palpi* pediform, anterior pair without claws. *Abdomen* without segments or elongated tail. *Spiracles* two. *Anus* furnished with an apparatus for spinning.

2. Scorpionidea.—M'Leay. (*Scorpio*, L. Latr.)

Def.—*Mandibles* chelate. *Head* and *trunk* coalite. *Anterior palpi* chelate. *Posterior palpi* pediform. *Pectens* two. *Abdomen* divided into segments, and terminating in a jointed tail, armed at the end with a sting. *Spiracles* four pair.

3. Galeodea.

Def.—*Head* distinct. *Eyes* two. *Mandibles* chelate, with dentated chelæ. *Palpi* pediform, the anterior pair thickest, with a retractile sucker. *Trunk* consisting of two principal segments, with a minute supplementary posterior one. *Spiracles* two, placed in the trunk. *Pseudo-pectens* two. *Abdomen* divided into segments. *Anus* unarmed, and without a spinning apparatus.

4. Phrynidea.

Def.—*Mandibles* unguiculate. *Anterior palpi* chelate or unguiculate, very robust. *Posterior palpi* pediform, very long and slender. *Abdomen* divided into segments. *Spiracles* two pairs. *Anus* terminating in a mucro, and sometimes in a filiform jointed tail, without a sting at the end.[4]

In the *Règne Animal* (2d edition, 1829), Latreille includes in the class Arachnides only those species which correspond to the *Arachnides palpistes* of M. Lamarck. By this arrangement he is of opinion they may be classed and defined in a more simple and rigorous manner. According to his most matured views, then, the Arachnides, like the Crustacea, are destitute of wings, and are not subject to metamorphoses, but only to simple changes. Their sexual organs are removed from the posterior extremity of their bodies, and situated, with the exception of certain males, at the base of the abdomen. They bear a resemblance to insects in as far as the surface of their bodies present openings or transverse clefts named *stigmata*, for the entrance of air, but in smaller number than in insects (eight at most, generally two), and placed only at the inferior part of the abdomen. Their respiration is farther carried on either by aerial branchia, performing the office of lungs, inclosed in the cells of which the openings just mentioned are the entrance, or by means of radiated tracheæ. The organs of vision consist of small simple eyes, variously grouped when numerous. The head, usually distinct from the thorax, presents, as analogous to the antennæ of insects, two articulated appendages, in the form of small talons of two or more pieces, which have been improperly compared to the mandibles of insects, though moving in a different direction. They, however, cooperate in the action of the jaws, and are represented in those Arachnides of which the mouth is formed like a syphon or sucker by two pointed plates or lancets.[5] A sort of lip (*labium*, Fab.), or rather tongue, formed by a pectoral prolongation; two maxillæ, formed by the radical part of the first article of two small feet or palpi,[6] or by a lobe or appendage of that article; a beak-shaped projection, named sternal tongue (*langue sternale*) by M. Savigny, produced by the re-union of a very small chaperon, terminated by a minute triangular lip, and of a longitudinal inferior keel, usually hairy:—these, and the parts called mandibles, compose, under certain modifications, the general structure of the mouth in the class Arachnides. The pharynx is placed in advance of a sternal projection, which has been regarded as a lip; but when we consider its position behind the pharynx, and the absence of palpi, it is probably rather analogous to a tongue (*languette*). The feet, like those of insects, are generally terminated by two crotchets, sometimes by three, and are all attached to the thorax, which is almost always formed of a single articulation, for the most part intimately united to the abdomen. The abdomen in the greater proportion of species is soft, or but slightly protected.

When considered in relation to their nervous system, the Arachnides are obviously distinguished both from the Crustacea and Insects; for, with the exception of the scorpions, the ganglia or swellings of the nervous cords never exceed three in number.

The greater proportion of Arachnides feed on living insects, the bodies of which they seize or adhere to, and

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[1] Leon Dufour, *Six Nouv. Arach. &c. Ann. Gen. des Sciences Physiq.* iv. iii. 17, t. lxix. f. 7. b.
[2] *Mém. sur les Anim. sans Vertèbres.* [3] *Introduc. to Entom.* vol. iv. p. 386. (1826.) [4] *Ibid.* p. 388.
[5] *Chelicères* or *Antenne-pinces* of the French writers.
[6] According to Latreille, these do not differ from feet properly so called, except in the tarsi, composed of only a single joint, and usually terminated by a small crotchet; they almost entirely resemble the ordinary feet of the Crustacea.

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suck their juices. Others are parasitical on the bodies of vertebrated animals. A few, such as certain mites, feed on cheese, and on flour and other vegetable productions. In some of the species two of the feet are not developed till the animals have changed their skin; and in general it is not till after their fourth or fifth moult, or casting of their exuviæ, that the Arachnides attain to their completed state.[1]

The following tabular view exhibits the classification and relative position of the orders and genera of this extensive class.

CLASS ARACHNIDES.

ORDER I.—PULMONARIÆ.

FAMILY I.—ARANEIDES.

SECT. I.—*Tetrapneumones.*

Genus 1. Mygale.
2. Cteniza.
3. Atypus.
4. Erodion.
5. Dysdera.
6. Filistata.

SECT. II.—*Dipneumones.*

A.—Sedentariæ.

Tribe 1.—*Tubitelæ.*

Genus 7. Clotho.
8. Drassus.
9. Segestria.
10. Clubiona.
11. Aranea.
12. Argyroneta.

Tribe 2.—*Inæquitelæ.*

Genus 13. Scytodes.
14. Theridion.
15. Episinus.
16. Pholcus.

Tribe 3.—*Orbitelæ.*

Genus 17. Linyphia.
18. Uloborus.
19. Tetragnatha.
20. Epeira.

Tribe 4.—*Laterigradæ.*

Genus 21. Micrommata.
22. Senelops.
23. Philodromus.
24. Thomisus.

B.—Erraticæ.

Tribe 5.—*Citigradæ.*

Genus 25. Oxyopus.
26. Ctenus.
27. Dolomedes.
28. Lycosa.
29. Myrmecia.

Tribe 6.—*Saltigradæ.*

Genus 30. Tessarops.
31. Palpimanus.
32. Eresus.
33. Salticus.

FAMILY II.—PEDIPALPI.

Tribe 1.—*Tarentulæ.*

Genus 34. Phrynus.
35. Thelyphonus.

Tribe 2.—*Scorpionides.*

Genus 36. Buthus.
37. Scorpio.

ORDER II.—TRACHEARIÆ.

FAMILY I.—PSEUDO-SCORPIONES.

Genus 38. Galeodes.
39. Chelifer.

FAMILY II.—PYCNOGONIDES.

Genus 40. Pycnogonum.
41. Phoxichilus.
42. Nymphon.
43. Ammothea.

FAMILY III.—HOLETRA.

Tribe 1.—*Phalangita.*

Genus 44. Phalangium.
45. Gonoleptes.
46. Siro.
47. Macrocheles.
48. Trogulus.

Tribe 2.—*Acarides.*

Genus 49. Trombidium.
50. Erythræus.
51. Gamasus.
52. Cheyletus.
53. Oribata.
54. Uropoda.
55. Acarus.
56. Bdella.
57. Smaridia.
58. Ixodes.
59. Argas.
60. Eylais.
61. Hydrachna.
62. Limnochares.
63. Caris.
64. Leptus.
65. Aclysia.
66. Astoma.
67. Ocypete.

We shall now proceed to the first subdivision of the class into two great orders.

ORDER I.—ARACHNIDES PULMONARIÆ.

Characterized by the possession of pulmonary sacks, a heart with distinct vessels, and from six to eight simple eyes. The sacks contain aerial branchia, which perform the office of lungs, and are named pneumo-branchia by Latreille. They are placed under the abdomen, and are indicated externally by *stigmata* or small transverse openings, of which there are sometimes four on each side, sometimes only four in all, or two on each side. The eyes vary in number from six to eight,[2] whereas in the subsequent order (*Trachearia*) there are never more than four. The respiratory organ is formed of small plates. The heart is a

[1] Latreille has observed, in conformity with the experience of Jurine *fils*, that the *Argulus* of Müller does not acquire the faculty of generating till after the completion of the sixth moult. Caterpillars generally change their skins four times before they assume the form of the chrysalis, which, with the final transformation to the perfect state, causes the number of moults to amount also to six.

[2] The genus *Tessarops* of M. Rafinesque is described as having only four eyes; but M. Latreille is of opinion that the lateral pair had been overlooked.

large vessel, which stretches along the back, and gives off branches forwards and on either side.[1] The feet are constantly eight in number. The head is always confounded with the thorax, and presents two pincers (*mandibulæ* of authors, *chelicères* or *antenne-pinces* of Latreille) terminated by two finger-like projections, of which one is movable, or by a single hook or claw, always movable. The mouth is composed of a lip (*labium*); of two palpi, which sometimes assume the shape of arms or talons; of two or four maxillæ, formed, when there is only a pair, by the radical article of the palpi, and when there are four, by that same article and the corresponding portion of the first pair of feet; and of a languette of one or two pieces. If we were to assume as a basis the progressive diminution in the number of the pulmonary sacks and stigmata, then the scorpions which have eight, while the other Arachnides have only four or two, would form the leading genus of the class, and the family of *Pedipalpi* would take precedence of the *Araneides* or spinners; but these last-named Arachnides are to a certain extent isolated, by reason of the sexual organs of the male, by the hook of their frontal talons, by their pediculated abdomens, and the peculiarities of their spinning apparatus, as well as by their natural habits; and the scorpions also appear to form a more natural transition from the pulmonary Arachnides to the family of the pseudo-scorpions, the first of the second order.

Of all the Arachnides the *Pulmonariæ* exhibit the greatest analogies to the crustaceous class, especially to the genus Limulus and others of the pæcilopodous order. The pneumo-branchia and their stigmatiform openings may frequently be detected externally by yellowish-white markings, disposed in two longitudinal series. The first two are placed immediately beneath the sexual organs, at least in the females, at a small distance from the origin of the abdomen, and on its second segment, when that part is annular or divided into segments. Thus the second segment in these Arachnides corresponds in its characters to the first segment of the female Limulus. We may also perceive in them the indications of conglomerated glands, and even in certain species traces are observable of chiliferous vessels.

The claw of the mandibles in spiders, and the terminal joint of the tail in scorpions, form a species of dart, perforated by one or two openings, which give issue to a poisonous liquid secreted by special glands. This poison is mortal to such small creatures as form the natural prey of the Arachnides, and is even productive of dangerous consequences to man and the larger animals. Its mode of action on animals unprovided with a circulating system is not clearly understood, but the phenomena attending it might reasonably be adduced in support of that theory which advocates the agency of poison from the bite of venomous reptiles as being carried on as much through the medium of the nervous as the circulating fluid. The almost instantaneous death of animals from the bite of certain snakes has been regarded as a proof that the vascular system was not alone concerned; and the same sudden effect produced upon those classes in which, as far as we can perceive, no vascular system exists, demonstrates some other mode of action.

Notwithstanding the researches of Cuvier, Marcel de Serres, Leon Dufour, Treviranus, and other observers, our knowledge of the internal organization of several genera of Arachnides is extremely deficient. Hence it is difficult to trace the boundaries of the orders in a manner at once natural and precise. At the same time it has been remarked, that the accurate observation of the eyes and other external organs furnish characters which coincide with the distinctions deduced from internal structure, as far as the latter has been ascertained.

Family I.—Araneides.

This extensive family corresponds to the genus Aranea of Linnæus, and contains all those species commonly called spiders—the *Arachnides fileuses* of Latreille. The characters are, two or four branchial pouches; from six to eight simple eyes; last article of the mandibles (*chelicères*) in the form of a corneous claw, perforated at the extremity for the emission of poison, and folded upon the preceding joint; abdomen usually soft, without divisions, its extremity furnished with from four to six small teat-like appendages, pierced with numerous holes for the passage of the silk or spinning materials;[2] feet palpi, without pincers at the extremity, but terminated in the female by small hooks, and in the male by the generative organs. The maxillæ are never more than two in number. The languette consists of a single piece, always external, and placed between the maxillæ; its form more or less square, sometimes triangular or semicircular. The thorax, usually impressed with a form resembling the letter Y, indicating the space occupied by the head, is composed of a single article. The legs, of which the forms are analogous, though the dimensions differ considerably, are composed of seven joints, of which the first two form the haunch, the third the thigh, the fourth and fifth the leg, and the remaining two the tarsi; the last is terminated by a couple of hooks, which are usually toothed or pectinated, and in many species there is an additional tooth of smaller size, but not pectinated. The intestinal canal is straight: there is first a stomach composed of several sacks; and towards the middle of the abdomen a second dilatation occurs. According to Marcel de Serres the heart is situated in the abdomen, and stretches throughout its whole length; there is a considerable swelling towards its superior extremity, after which it assumes and retains the cylindrical form. It is very muscular, and its pulsations are strong and frequent. The pulmonary pouches, usually two in number, are always situated on the lower surface of the abdomen, near its origin, and are covered by a coriaceous skin, generally of a red colour; the stigmatiform opening proper to each pouch is placed towards its base, on the inner side. These pouches are formed of a white membrane, strong but flexible, which presents on its interior, transverse, projecting, parallel, nearly semicircular folds or plates, which constitute the respiratory organ. The liver is proper to the abdomen, of which it occupies the chief portion. It is composed of an infinity of minute glands fixed to the intestinal canal, and filled with a peculiar liquid, thick, and of a brown colour. The interior of the abdomen also contains the silk vessels, four in number, long, cylindrical, folded, yellow. They open into a common canal, situated at the origin of the spinners.

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[1] According to M. Marcel de Serres (*Mémoire sur le Vaisseau Dorsal des Insectes*), the blood in the araneides and scorpions proceeds first to the respiratory organs, and from thence by special vessels to the various parts of the body. Latreille, however, seems to think, from the relations which exist between these creatures and the crustaceous tribes, that such circulation may be effected in the contrary direction. See the *Règne Animal*, tome iii. p. 212; and a memoir by Treviranus *On the Internal Organization of Arachnides*. 1 vol. 4to, Nuremberg, 1812.

[2] Some naturalists are of opinion that the two small spinners placed in the centre of the four exterior ones yield no silk.

Arachnides.

The nervous system consists, 1*st*, of a cerebriform ganglion, placed towards the base of the thorax, quadrangular in some, in others rounded—from it proceed whitish nervous threads to the mouth, eyes, and feet; 2*dly*, of two nervous cords, derived from the above ganglion, which occupy the median line of the body, and of ganglia which distribute nervous filaments to the different organs, and principally to the alimentary canal and the silk vessels. M. Dufour did not ascertain the number and disposition of these latter ganglia. According to Treviranus they do not exceed two.

The dorsal and abdominal region of many spiders exhibit several small depressed points, which are produced by the attachment of the filiform muscles which traverse the liver. These are likewise observable in the scorpions.[1]

The silk vessels with which both sexes of many species fabricate those webs so remarkable at times for their symmetrical form and exquisite delicacy of structure, vary in shape and position according to the habits of the species. The formation by these creatures of skilfully wrought nets for the capture of their prey, is a fact of such every-day occurrence and observation, that we cease to regard it in its proper light, as one of the most admirable and surprising instincts of animal life. According to Reaumur, the silk undergoes its first elaboration in two small reservoirs, shaped like a drop of glass placed obliquely, one on each side, at the base of six other reservoirs in the form of intestines, which lie side by side, and folded six or seven times. The latter derive their origin from a little below the commencement of the abdomen, and proceed to the nipples by a slender thread. It is in the last-named vessels that the silk acquires that greater consistence and those other qualities which render it fit for use. A certain degree of dryness or evaporation seems necessary for the proper formation of the threads; but when the atmosphere is in a favourable condition the requisite change appears to take place almost instantaneously.

Various opinions have been entertained regarding the origin of those white, flaky, filamentous, silky substances which are frequently found floating in the atmosphere during the mornings of spring and autumn. They are called *fils de la vierge* by the French, and Lamarck still maintains the opinion that they are meteoric productions. The results of chemical analysis, as well as of ordinary observation, render it little less than certain that they are produced by small spiders of the genera *Epeira* and *Thomisus*. The innumerable threads which the sun-beams occasionally bring to view over the entire surface of ploughed fields are also formed by spiders of the genus Lycosa. Latreille is of opinion that many of these creatures, before they are sufficiently provided with spinning materials to form webs, content themselves by ejecting simple longitudinal threads. They are merely apprentices to the weaving art.

The habits of spiders vary greatly. Some rest in the centre of their webs, the outstretched cordage of which warns them of the temporary entanglement of their prey, on which they instantly rush, and devour after the infliction of a mortal wound. Others seek the protection of a leaf or other natural harbour, and only appear in the more open parts of their premises when lured by an expected capture. Many spin comfortable tunnels, or horizontal watchtowers, as they may be called, in which they repose till the vibration of their nets calls them into active service. An extensive tribe of erratic species (the *vagabundæ*) spin no webs at all, but trust to strength, activity, and cunning, for their daily, or, it may be, monthly fare; for spiders, though voracious in times of abundance, are capable of frequent and long-continued abstinence. The webless species are often endowed with the faculty of leaping, and after insidiously approaching their prey by the most wary and almost imperceptible footsteps, they spring upon it at once, and inflict the fatal wound. Several kinds hunt down their insect food by speed of foot; and a few are nocturnal, and surprise their defenceless and unsuspecting victims during the darkness of the night. According to Mr Sheppard, a large species, which occurs among the fen ditches of Norfolk, actually constructs a sort of raft of weeds, or floating island, on which it allows itself to be wafted about, and from which it seizes upon drowning insects; and another (*Lycosa piratica* of Walckenaer) gives chase to its prey over the surface of the water.

> Unwet they bathe their oily forms, and dwell
> With feet repulsive on the dimpling well.

The passion of love, so powerful in its influence over the most savage beasts, rules with a feeble and transitory sway over the subjects of our present inquiry. The male spider approaches the female with the greatest circumspection, fearful lest the sexual feeling should not have banished that thirst for blood which under ordinary circumstances induces them to prey as readily on each other as on winged insects. It therefore not unfrequently happens, that if a small male approaches a large female, whose feelings unfortunately do not coincide with his own, instead of being caressed he is eaten. According to Audebert, the female of the domestic spider is capable of producing successive generations without any renewal of intercourse with the male. He also states that he kept the same individuals in life for five or six years.

All female spiders, including even the erratic and webless species, are provided with reservoirs of silky matter, which, if not used in spinning, are at all events employed in forming a protecting covering for the eggs. The most casual observer of nature must have frequently remarked the care with which the anxious mother carries about and watches over her unhatched offspring; and the delicate colour of the silken bag which contains the eggs, and the fine contrast which in some cases it presents to the body of the parent, cannot have escaped observation. The truth is, that spiders, though frequently of a repulsive aspect, are as often distinguished not only by great beauty of colour, but by extreme elegance of form and delicacy of structure. We are prejudiced against the race in general, because all those that dwell within doors are of a dark and lurid hue, and from their haunts and habits have become objects of aversion and disgust. Thomson has well described,

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[1] "L'organe reproducteur du male est formé de deux verges qui s'ouvrent à l'extrémité des palpes, et communiquent chacune avec un testicule en forme de poire, qu'on observe dans le thorax. On voit souvent à coté des verges deux crochets, servant au male à saisir la femelle. L'organe reproducteur de ces derniers individus est placé dans l'abdomen. Il est composé de deux valves, situées vers le milieu de sa partie inférieure, et près de son origine; à leurs deux ouvertures correspondent les oviductus, dont les membranes, en se développant, forment les ovaires. Ces organes ne sont point composés de canaux cylindriques, et ne consistent qu'en une membrane générale, enveloppant tous les œufs, et se divisant seulement vers sa base en deux parties qui se prolongent et constituent les oviductus. On decouvre vers la base des valves un organe particulier, analogue à l'oviscapre des femelles des insectes, coriace, ayant la figure d'un cuilleron, plus large vers son origine qu'à l'extrémité, ou il est assez allongé, et jouissant d'une certaine mobilité. Il parait fournir la matière soyeuse qui recouvre les œufs ou leurs cocons." (*Dict. Class. d'Hist. Nat.* tome i. p. 509.)

Where gloomily retired,
The villain spider lives, cunning and fierce,
Mixture abhorred! amid a mangled heap
Of carcases, in eager watch he sits,
O'er-looking all his waving snares around.
Near the dire cell the dreadless wanderer oft
Passes,—as oft the ruffian shows his front;
The prey at length ensnared, he dreadful darts
With rapid glide along the leaning line;
And fixing in the wretch his cruel fangs,
Strikes backward grimly pleased; the flutt'ring wing,
And shriller sound, declare extreme distress,
And ask the helping hospitable hand.

But many of those which live in fields, woods, and gardens, are worthy of being admired for their beauty, no less than for their singular instincts and remarkable modes of life.

The external appearance varies considerably in the same species, according to the age of the individual. The younger they are, the less varied is their colouring. The number and colour of the eggs differ according to the species. There is seldom more than a single laying of eggs in each year. In some species the eggs are free or unattached in the cocoons which contain them, in others they are fixed by agglutination. In the course of the summer season they are usually hatched in from fifteen to thirty days, according to the temperature. The eggs of such as deposit in autumn (as *Epeira diadema*, a fine species, which occurs in gardens, near the outskirts of woods, and in moors and furzes) are, however, seldom hatched till the commencement of the ensuing spring.

Some species of spider appear to possess the power of reproducing lost or mutilated parts, after the manner of the Crustacea. It is somewhere remarked, that in proportion to the simplicity of organic structure in an animal, its body is more capable of repairing by reproduction such portions as have been destroyed or deteriorated. This would induce the belief that frogs and lizards are lower in the scale than insects, and that the latter, which do not possess the reproductive power, are more highly organized than spiders and other Arachnides. This, however, is not the case; and we may therefore infer that the principle itself is erroneous, or at least incapable of general application. The ascertainment of the fact, that spiders were capable of effecting this repair of parts, is due to the ingenious observations of MM. Vincent Amoreux and Amédée Lepelletier. It was also, however, observed by Sir Joseph Banks in this country, and communicated by him to Dr Leach, by whom the circumstance was recorded in the Supplement to the sixth or preceding edition of this work.

As Sir Joseph was writing one evening in his study, a web-spinning spider, above the medium size, passed over some papers on the table, holding a fly in its mouth. Surprised to see a spider of this description walking about with its prey, and struck with something peculiar in its gait, he caught and placed it under a glass for examination, when he perceived, that instead of eight legs, it had only three. This mutilation accounted sufficiently for its inability to spin a web; but the singular circumstance of its having changed its natural habits, and having become a hunting instead of a spinning spider, and his desire to ascertain whether its limbs would be reproduced, induced Sir Joseph to prolong its captivity. On the following morning the creature destroyed two flies by sucking out their juices, leaving the bodies entire. Two or three days afterwards it devoured the body and head of a fly, leaving only the wings and legs. After this time it sometimes sucked and sometimes swallowed the flies.

Soon after its confinement it attempted to form a web on the side of the vessel, but performed the operation very slowly and awkwardly, owing to the want of the proper number of legs. However, in the course of about a fortnight it had completed a small web, upon which it generally sat, and no doubt regarded with complacency. A month after being caught it shed its skin, leaving the slough on the web. After this change five new legs began to appear, which for a short period were of little or no use to it in walking. These new members, however, extended themselves considerably in the course of three days, and became about half as long as the old ones. The web was now increased, and the spider continued immovably sitting on it in the day-time, unless drawn from it, or attracted by a fly thrown to it as its usual provision. Twenty-nine days afterwards it again cast its skin, leaving the slough hanging in the web, opposite to a hollow cell it had woven so as to prevent itself from being completely seen. The legs were now larger than before the change of the skin, and they continued to increase for several days, but did not attain the size of the old legs. It was then put into a small bowl as a more commodious and convenient residence, where it spun a larger and more perfect web. We are not acquainted with the result of any further observations on the subject.

Various attempts have been made at different periods to fabricate gloves and stockings from the silk of the spider. Nearly a century ago, Bon of Languedoc succeeded in making a pair of each of these articles from this frail material: they were nearly as strong as those of common silk, and of a fine gray colour. Reaumur was appointed by the Royal Academy to report on the advantages which might result from the regular prosecution of a manufactory from spider-silk; but his opinion was, that the natural fierceness and voracity of spiders rendered them entirely unfit to be bred and brought up together. From 4000 to 5000 were distributed in cells, each containing from 50 to 200 individuals; but in a short time only a few were left alive. He also stated, that the web of the spider was not equal to that of the silk-worm, either in strength or lustre. The cocoons of the latter weigh from three to four grains, so that 2304 worms produce a pound of silk. But the bags of a spider, when cleaned of filth and dust, do not weigh above the third part of a grain, so that the work of twelve spiders does not exceed that of a single silk-worm, and to form a pound of silk 27,648 spiders would be required; and as it is the females alone that spin the bags, if they are kept in pairs for the purpose of breeding, 55,296 individuals would be necessary to the formation of every pound. Even this calculation applies only to good spiders of the domestic breed, for those found in gardens scarcely yield the twelfth part of silk of the house species; therefore 280 would not produce more than a single silk-worm, and 663,555 would scarcely yield a pound of silk.[1]

Sir George Staunton, in his *Embassy to China*, states that spiders' webs are met with in the forests of Java of so strong a texture as to require to be cut through with a knife; and in the *Philosophical Transactions* (1668) we are informed that the spiders of Bermudas suspend their webs between trees seven or eight fathoms distant, and that they are so strong as to entangle birds as large as thrushes. "The web of a house-spider," observe Messrs Kirby and Spence, "will, with occasional repairs, serve for a considerable period; but the nets of the geometric spiders are in favourable weather renewed, either wholly, or at least their concentric circles, every twenty-four hours,

[1] *Memoirs of the Academy*, 1710.

even when not apparently injured. This difference in the operations of the two species depends upon a very remarkable peculiarity in the conformation of their snares. The threads of the house-spider's web are all of the same kind of silk, and flies are caught in them from their claws becoming entangled in the fine meshes which form the texture. On the other hand, the net of the garden spider is composed of two distinct kinds of silk; that of the radii not adhesive, that of the circles extremely viscid. The cause of this difference, which, when it is considered that both sorts of silk proceed from the same instrument, is truly wonderful, may be readily perceived. If you examine a newly formed net with a microscope, you will find that the threads composing the outline and the radii are simple, those of the circles closely studded with minute dew-like globules, which from the elasticity of the thread are easily separable from each other. That these are in fact globules of viscid gum, is proved by their adhering to the finger, and retaining dust thrown upon the net, while the unadhesive radii and exterior threads remain unsoiled. It is these gummed threads alone which retain the insects that fly into the net; and as they lose their viscid properties by the action of the air, it is necessary that they should be frequently renewed."[1]

Dr Lister was of opinion that spiders possessed the power of again withdrawing their webs within their bodies,—a fact which, with Degeer, we may reasonably doubt, when we consider the immediate atmospheric change which takes place in the nature of the thread after it is once protruded. In fact, when a spider ascends on the same cord by which it had previously dropped from a height, a small ball or rounded web will be found adhering to it, composed of the coil which it has collected in its re-ascent. The extreme tenuity of the component or elementary threads of the spider's web has been well explained by Leeuwenhoeck. He states that the threads of the minutest spiders, some of which are not equal in bulk to a grain of sand, are so fine that four millions of them would not exceed the thickness of a human hair. Now we know that each spinner, of which there are four, is pierced by about a thousand holes, consequently that every compound or ordinary thread is composed of 4000 still finer. Thus a spider's thread, of the thickness of a human hair, may in some instances be composed of not fewer than *sixteen thousand millions* of single threads!

The bite of an ordinary spider occasions almost instant death to most insects. The great species of South America attack vertebrated animals, such as humming-birds and young pigeons, and their bite is often attended with dangerous consequences even to the human race. Spiders are themselves preyed upon by birds; and a winged insect of the genus *Sphex* pierces them with its sting, carries them off, and buries them dead or alive in holes where its eggs are deposited, the larvæ produced from which afterwards feed upon the dead body of the spider. Most species perish about the commencement of winter, although many others are known to exist for several years. According to Sparmann, they form an article of food to the Bosjiesmen of Southern Africa; and Labillardiere relates, that the inhabitants of New Caledonia eat with avidity great quantities of a spider nearly an inch long (*A. edulis*), which they roast over the fire.[2]

The ascent of spiders into the air, and the extension of their webs from tree to tree across an open space, or even over a running stream, have frequently excited the attention of naturalists. Dr Lister relates, that attending minutely to a spider at work weaving its net, he observed it suddenly desist, and, turning its nipples to the wind, dart out a thread with the violence of a water jet. This thread, taken up by the wind, was carried to some fathoms' length, still issuing from the body of the animal. Some time after the spider leapt into the air, and the thread mounted her up swiftly. He afterwards made the same observation on about 30 other species of spiders, and found the air filled with young and old sailing on their threads, and probably seizing insects in their passage, as he found legs and wings, and other manifest signs of slaughter, on these threads, as well as on the webs below. These observations were corroborated by Dr Hulse, who made the like discovery about the same time. It is Dr Lister's opinion that this darting of threads was known to Aristotle and Pliny (vide *Hist. Anim.* lib. ix. cap. 89; and *Plin.* lib. x. cap. 74), but he believes their sailing was first observed by himself. On these sailing spiders he further observes, that they will often dart, not a single thread alone, but a whole sheaf at once, consisting of many filaments, all of one length, but divided from each other, and distinct; and the longer they become, the more they spread, and appear like the numerous rays of a blazing star. He observed, too, that some species seemed to use their legs as oars, sometimes closing, and again spreading them out, as occasion might require. When the air is still it is highly probable they can direct their course, and perhaps mount or descend at pleasure. In rowing, he observed they always take their flight backwards. These threads mount to an almost incredible height, and may always be observed in a fine clear day in autumn, when there is little or no wind. In a letter to Mr Ray, he further states, that "I one day observing the air full of webs, forthwith mounted to the top of the highest steeple on the minster (at York), and could there discern them exceedingly high above me."

If a spider is placed on the top of a pole surrounded by water, it nevertheless effects its escape by means of a silken line, which is ere long found to extend from the pole to some other object on the outside of the pool. It is evident that the spider possesses the power of permitting the material of which its threads are composed to escape at pleasure; but whether this is accomplished by a projectile force, by electrical agency, or by the mechanical action of the external currents of the atmosphere, is still a subject of dispute. The beautiful regularity with which the radiated parts of the web are usually disposed favours the idea expressed by a French writer, that the animal possesses the power of shooting out its threads and directing them at pleasure towards a determined point; whilst the observations of Messrs Rennie and Blackwall indicate the necessity of a current of air as a moving force. It appears, from the experiments of the latter gentleman, that when spiders are placed upon an insulated twig surrounded by water, and exposed to a current of air, however slight, either naturally or artificially produced, they directly turn the thorax towards the quarter from whence it came, and elevating the abdomen, they emit from their spinners a small portion of glutinous matter, which is instantly carried out in a line, consisting of four finer ones, with a velocity equal or nearly so to that of the air. They next carefully ascertain whether their lines have become firmly attached to any object, by pulling at them with their anterior pair of legs; if the result satisfies them, they glue the nearer end to the twig, and then march across. "Such was invariably the result when spiders were placed where

[1] *Introduction to Entomology*, vol. i. p. 414.
[2] *Voyage à la Recherche de la Perouse; Introduction to Entomology*, vol. i. p. 302.

the air was liable to be sensibly agitated: I resolved therefore to put a bell glass over them, and in this situation they remained 17 days, evidently unable to produce a single line by which they could quit the branch they occupied, without encountering the water at its base; though, on the removal of the glass, they regained their liberty with as much celerity as in the instances already recorded." (*Linn. Trans.* vol. xv.) Mr Blackwall affirms with confidence, that in motionless air, spiders have not the power of darting their threads even through the space of half an inch. Mr Murray, Mr Bowman, Mr Mark Watt, and others, maintain a contrary opinion.

Lastly, Mr Virey thinks it more probable that spiders actually fly (by vibrating their feet) through the air, than that they are acted upon either by electrical influences or the agitation of the air. He does not assert that they have wings.

The bodies of spiders decompose so rapidly after death, that both their forms and colours are speedily altered and effaced. It is therefore with great difficulty that they are preserved as subjects of examination in museums. Hence, perhaps, our comparative ignorance both of their structure and habits.

Sect. I.—Tetrapneumones.

Two spiracles and two pulmonary sacks or pneumobranchia on each side.

This section is characterized by the position of the eyes, which are always placed at the anterior extremity of the thorax, and usually close to each other. The mandibles (*chelicères* of Latreille) and feet are robustly formed. The greater proportion of species have only four spinners. They fabricate silken tubes, in which they dwell, and these are placed sometimes in subterranean tunnels, sometimes under stones, and sometimes beneath the bark or among the leaves of trees.

The first division of the section corresponds to the *Theraphoses* of Walckenaer, and contains the three following genera, viz. Mygale, Atypus, and Erodion. These are distinguished from the others by having four spinners and eight eyes, and by the hooks of their mandibles being bent underneath instead of inwards.

Genus Mygale, Walckenaer.—Palpi inserted at the superior extremity of the maxillæ, in such a manner that they appear to be composed of six articles, of which the first, straight and elongated, with the inner angle of its upper portion projecting, performs the function of a jaw. The languette is small and nearly square. The last joint of the palpi in the male is button-shaped, and bears at its extremity the reproductive organs; and the two anterior legs in that sex are provided with two strong spines or spurs at their inferior extremity.

This genus, as established by Walckenaer, is composed of the bird-catching spiders (*A. avicularia*, Linn.), and the *Araignées mineuses* of Olivier. It contains several species of great size and singular habits. The foreign kinds are as yet imperfectly characterized. The habits of a large species found in Martinique, where it is called *Matoutou*, have been well described by Moreau de Jonnés. It spins no web, but lies concealed in holes and crevices of the volcanic tufa, from which, however, it makes frequent excursions in search of prey, which consists not only of insects, but of humming-birds and other species of the feathered race. It hunts chiefly during the night. It is possessed of great muscular strength, and unwillingly quits an object of which it may have become possessed. When induced to seize upon any hard and polished substance, it leaves traces of a poisonous liquid, which, had the substance been of a yielding nature, it would have injected into the wound. This liquid is lactescent, or of a milky aspect, and very abundant in proportion to the size of the animal. The female carries her eggs in a cocoon of white silk, of a very close texture, which she holds by means of her palpi, beneath the thorax. When attacked, she drops her eggs to defend herself, and secures them again when the combat has ceased. The young, when first produced, are entirely white; and the earliest change which they experience is the appearance of a black spot in the centre of the dorsal surface of the abdomen. From eighteen hundred to two thousand young have been observed to proceed from a single silk bag; but of these it is probable that an immense proportion perish in infancy, by the depredations both of birds and insects.

Several species of this genus inhabit Europe, and their characters and economy are detailed by Olivier, Latreille, the Abbé Sauvage, and other writers. Our restricted limits prevent our describing more than a few, which we shall select as well from the indigenous as exotic.

† Superior extremity of the mandibles unprovided with a series of transverse spines or corneous points. Tarsi furnished with a thick hairy brush, which conceals the crotchets.

Sp. Avicularia.—Aranea Avicularia, Linn. The bird-catching spider, Shaw. (See Plate L.)—Body nearly two inches long, very hairy, especially in the young. Thorax depressed, large, oval, truncated posteriorly. General colour black; the extremities of the palpi, the feet, and inferior hairs of the mouth, reddish. Hooks of the mandibles strong, conical, and very black. This species is said to dwell in the clefts of trees, and in hollows among rocks and stones. According to Madame Merian, it surprises small birds on their nests, and sucks their blood with avidity. It forms a tube-shaped cell, narrow at its posterior extremity, composed of a fine white semi-transparent tissue, resembling muslin. The cocoon of this species is like a large walnut in size and form. Its native countries are Cayenne and Surinam. Other nearly allied species also occur in those parts of South America, as well as in Africa and the East Indies. Their bite is dangerous, although the accounts given by Piso and other authors is no doubt exaggerated. To this section may be referred the *M. blondi* (see Plate L.), *cancerides*, *fasciata*, *atra*, and *brunnea* of Latreille.

†† Superior extremity of the first piece of the mandibles provided with corneous points like the teeth of a rake. The tarsi are not so covered with hair as to conceal the crotchets.

The species of this section inhabit dry and mountainous places, where they form tunnels or subterranean galleries, sometimes two feet in depth. At the entrance they construct a door, moving upon a hinge, and formed of silk and clay, undistinguishable from the surrounding soil. There is what we may not improperly call a mat of silk fastened to the inner surface of the door, on which the animal frequently reposes, probably for the sake of guarding the entrance, and being at hand to secure its passing prey. A fine silk tube, which is the proper dwelling, clothes the interior of the gallery. M. Dufour is of opinion that the females alone excavate the tunnels.

Sp. Cœmentaria.—Araignée mineuse, Dorthes. In *Linn. Trans.* ii. (See Plate L.)—The female of this species is about eight lines in length, of a reddish brown colour, somewhat pale on the edges of the thorax. The mandibles are blackish, and are each furnished near the articulation of the crotchet with five points, of which the innermost is the shortest. The abdomen is mouse-coloured, with darker spots. The first article of all the tarsi is

furnished with small spines, the crotchets of the last have a spire at their base, and a double range of pointed teeth. The spinners are but slightly projecting. The *M. carminans* of M. Latreille (2d edit. of the *Nouv. Dict. d'Hist. Nat.*) is supposed to be the male of this species. He differs in the greater length of his legs; in the crotchets of the tarsi, of which the teeth are more numerous; in the want of the spines, and the greater shortness of the spinners. His two anterior feet are terminated beneath by a strong spine.

This species inhabits Spain, the southern parts of France, and other shores of the Mediterranean. Its habits are presumed to be nocturnal, as it is never seen abroad or at work during the day.[1] It forms its tunnel in strong earth, free from stones, and on a sloping surface to avoid moisture. It resists the opening of its door with its utmost strength, and continues struggling in the entrance till the light has fairly entered, after which it retreats into the earth. The door is beautifully formed, and suspended on a hinge from above, so that it always shuts close of its own accord. It preys upon beetles and other large and strong insects. When its door is cut off or unhinged, it forms another in its place, which, according to Rossi, differs from the first in not being movable. The Italian author does not mention by what means its entrance and exit are then accomplished; but Latreille has suggested that the experiment may have been tried just before the commencement of winter, and that the second operculum was closed with a view to exclude the rigours of that inclement season.

In the following genera of this division the palpi are inserted upon an inferior dilatation of the external side of the maxillæ, and consist of only five articles. The languette, at first very small, as in the genus Atypus, afterwards becomes elongated and advanced between the jaws. The last joint of the palpi in both sexes is lengthened and antennated towards the extremity. The males are not provided with a strong spur at the extremity of the two anterior legs.

Genus Atypus, Latreille. Oletera, Walckenaer.—Languette very small, and almost covered by the external portion of the base of the maxillæ. Eyes contiguous, and grouped upon a tubercle.

Sp. Sulzeri, Latreille. *Aranea Picea*, Sulzer. (See Plate L.)—General colour blackish. Length of the body eight lines. Thorax nearly square, depressed posteriorly, enlarged and broadly truncated in front. The mandibles are strong, and their claw is furnished near the base with a tooth-like projection. The last article of the palpi in the male is pointed at the extremity.

This is the only species of the genus known in Europe. It was first described by Sulzer as a Swiss species (*Geschichte der Insecten*. Plate L. fig. 2). It has since been observed by several French entomologists at Sevres, near Paris, and was discovered in this country by Dr Leach, near Exeter. Its habits are curious and interesting. It constructs for its dwelling a silky seabbard, intermingled with moss, eight or ten inches long. Its direction is at first horizontal over the surface of the ground, and then perpendicular beneath the surface. The eggs are deposited at the bottom, enveloped in a white web. The animal itself is slow in its movements. It is most frequently met with in the month of July. It appears to have been described and figured by Roemer as the *subterranean spider*.

An American species, the *Atypus rufipes* of M. Milbert, of which the body is entirely black, and the feet rufous, occurs in the neighbourhood of Philadelphia.

Genus Erodion, Latreille. Missulena, Walckenaer.—This genus differs from the preceding in its straight, elongated languette, which projects between the jaws. Its eyes are spread over the front of the thorax.

Sp. Occatorius, Latreille, Walckenaer. (Plate II. fig. 11, 12).—Body black, about an inch in length. Brought from New Holland by M. Lesueur.

The second division of this section exhibits the prolonged languette of the Erodions, and the palpi composed of five articulations; but the claws of the mandibles are folded inwards instead of downwards. The spinners are six in number; and the first pair of legs, instead of the fourth, are the longest. Some of these Arachnides have only six eyes.

Genus Dysdera, Latr. Walck.—Eyes six, disposed in the form of a horse-shoe, opening outwards. Mandibles strong and projecting. Maxillæ straight, and dilated towards the insertion of the palpi.

Sp. Erythrina. (See Plate L.)—Mandibles and thorax sanguineous; colour of the legs lighter. Abdomen soft and silky, and of a grayish yellow.

Inhabits the south of France and England, beneath stones. It is rare in the latter country, but has been taken near Plymouth, Exeter, and London. A variety of this species has been described by Scopoli under the name of *Aranea hombergii*.

Genus Filastata, Latr.—Eyes eight, placed on a small elevation at the anterior extremity of the thorax. Mandibles small; maxillæ arched on their exterior side.

Of this genus the *F. testacea* of Walckenaer was discovered near Marseilles. The *F. bicolor* is described in the *Faun. Franc. Arach.* vi. 1–3.

Sect. II.—Dipneumones.

A. Sedentariæ.

The genera of this great division are possessed of only a pair of pulmonary sacks, and corresponding stigmata. The palpi, composed of five joints, are inserted on the exterior side of the maxillæ, near their base, generally in a sinus. The languette is advanced between the maxillæ, and is sometimes nearly square, sometimes triangular or semicircular. The spinners are six in number. The last article of the palpi in the males is more or less ovoid, and usually contains the generative organs in an excavation.

The first four tribes of this section may be considered as forming a large group, which we name *Sedentariæ*. They either spin webs for the capture of their prey, or throw out isolated and irregular threads for the same purpose. Their eyes are grouped across the front of the thorax. Of these there are usually eight; four or two in the centre, and two or three on each side. Sometimes there are only six eyes.

The first three of these tribes, viz. *Tubitelæ*, *Inæquitelæ*, and *Orbitelæ*, are sometimes included under the more general appellation of Rectigrade, from their straightforward mode of progression, particularly as contrasted with that of the fourth tribe or *Laterigradæ*, which, like many of the crustaceous class, can direct their steps in different directions without turning the body. In these tribes the relative length of the legs is variable. In many the first and the last pair are the longest; in others the two

[1] The eyes of spiders are occasionally observed to shine in the dark like those of cats, moths, &c., and they probably enjoy the faculty of seeing both by night and day.

anterior pairs; while in some the third and fourth pair are the most extended. The eyes, in their general disposition, do not form a crescent, or the segment of a circle.

TRIBE I.—TUBITELÆ.

Spinners cylindrical, close to each other, directed backwards. The feet are robust; the first and last pair are the longest.

GENUS CLOTHO, Walckenaer. UROCTEA, Dufour.—Mandibles very small, capable of little extension, and without teeth. Crotchets small, body short, legs long, the third and fourth pair rather longer than the preceding. The eyes are disposed as in genus Mygale. The maxillæ have on their external side a slight dilatation at the insertion of the palpi, and terminate in a point. The languette is triangular. The superior or lateral spinners are the longest; but the most peculiar character, according to M. Dufour, is the existence, in the position of the intermediate spinners, of a pair of comb-shaped valves, which open or close at the will of the animal.

Sp. 5-maculata.—Body about an inch in length, of a chesnut-brown colour; the abdomen black, with five small round yellowish spots, of which four are disposed transversely in pairs, and the fifth is single and posterior.

This species was found in Egypt by M. Savigny. It occurs in Dalmatia, and near Montpellier; also in Catalonia, and other parts of Spain. Its manners have been described by M. Dufour.

GENUS DRASSUS, Walck.—Mandibles robust, projecting, toothed beneath. Maxillæ obliquely truncated at their extremity. The eyes are nearer the anterior edge of the thorax, and the line formed by the four posterior exceeds in length that formed by those on the anterior line. The fourth and second pair of feet are obviously longer than the others. The legs and first joints of the tarsi are armed with sharp points.

The spiders of this genus live under stones, in the clefts of walls, and among leaves. They form little dwelling-places of white silk. The cocoons of some are orbicular, flattened, and composed of two valves applied one against another.

Sp. Relucens.—Small, cylindrical, with a yellow thorax, covered with a purple silky down. The abdomen is thin, red, and green, with metallic reflections, and two transverse lines of golden yellow, of which the anterior is arched. One variety has also four additional golden spots. The species is generally found running on the ground. It is common in the environs of Paris, and is one of the most beautiful of the tribe.

GENUS SEGESTRIA, Latr.—Eyes six, of which four are anterior on a transverse line, and two posterior, placed on each side behind the two lateral eyes of the preceding line. The languette is elongated and almost square. The first and second pair of feet are the longest, and the third pair the shortest.

The species of this genus spin cylindrical elongated webs in the clefts of old walls, in which they lie concealed, with their anterior pair of legs stretched forwards. Divergent threads of glutinous silk border the external opening to their habitation, and form a net for the capture of their insect prey.

Sp. Senoculata.—Thorax blackish-brown. Abdomen oblong, grayish, with a longitudinal band of blackish spots. Legs pale brown, obscurely banded. Inhabits rocks and old buildings.

GENUS ARANEA, Latr. TEGENERIA, Walck.—The two upper spinners conspicuously longer than the others. The four anterior eyes placed in a curved line, bending backwards. The first and last pair of legs the longest.

This genus inhabit the interior of our dwellings; also the angles of old walls, on plants, hedges, &c. They construct large webs, nearly horizontal, at the higher part of which is a tube or tunnel, where the spider lies concealed.

Sp. Domestica.—Of a livid ash colour. Thorax of the male without spots. On that of the female there is on each side a blackish band. Abdomen blackish, with a longitudinal spotted band on the back.

This is the most frequent inhabitant of our houses, and an object of more than common aversion. It sometimes attains to a large size. According to Homberg, it is subject, especially in the kingdom of Naples, to a disease which renders it more than usually hideous. Its body becomes covered with scales, among which a number of mites engender. Geoffroy was of opinion that a spider was supplied only with a certain portion of spinning material; that if the web was intentionally destroyed, and an individual frequently obliged to reconstruct its web, it became at last incapable of further exertion in that line, and would probably perish for want of the usual means of subsistence.

The spiders of this country are entirely harmless, from their want of power to pierce the skin. But that they are furnished with a poisonous liquid, which they instil into the wound of their victims, cannot be doubted. Olivier, indeed, reports, that a farmer in one of the Isles d'Hières was bitten by a large spider while turning a sheaf of wheat. The wound occasioned at first only a slight inflammation, so trivial that it was for some time neglected, till its increase created alarm. Gangrene and death ensued. They may be taken internally with impunity. "J'ai vue," says Latreille, "le célèbre astronome Lalande avaler de suite quatre gros individus de cette espèce." (*A. domestique.*)

GENUS ARGYRONETA, Latr.—Maxillæ inclined upon the languette, of which the form is triangular. The four central eyes form a quadrangle; the lateral pair of each extremity are grouped together, and placed on a small eminence.

Sp. Aquatica. Aranea Aquatica, Lin. Geoff.—Of a blackish-brown colour, the abdomen deeper, surface silky, the back with four impressed points. Lives in ditches and slow-running waters, beneath the surface of which it spins a beautifully constructed web. "The habitation of *aranea aquatica*, the other spider to which I alluded, is chiefly remarkable for the element in which it is constructed, and the materials that compose it. It is built in the midst of water, and formed in fact of air! Spiders are usually terrestrial; but this is aquatic, or rather amphibious: for though she resides in the midst of water, in which she swims with great celerity, sometimes on her belly, but more frequently on her back, and is an admirable diver, she not unfrequently hunts on shore, and having caught her prey, plunges with it to the bottom of the water. Here it is she forms her singular and unique abode. She would evidently have but a very uncomfortable time were she constantly wet; but this she is sagacious enough to avoid, and, by availing herself of some well-known philosophical principles, she constructs for herself an apartment, in which, like the mermaids and sea-nymphs of fable, she resides in comfort and security. The following is the process:—First she spins loose threads in various directions, attached to the leaves of aquatic plants, which may be called the frame-work of her chamber; and over them she spreads a transparent varnish resembling liquid glass, which issues from the

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middle of her spinners, and which is so elastic that it is capable of great expansion and contraction; and if a hole be made in it, it immediately closes again. Next she spreads over her belly a pellicle of the same material, and ascends to the surface. The precise mode in which she transfers a bubble of air beneath this pellicle is not accurately known; but from an observation made by the ingenious author of the little work from which this account is abstracted, he concludes that she draws the air into her body by the anus, which she presents to the surface of the pool, and then pumps it out from an opening at the base of the belly, between the pellicle and that part of the body, the hairs of which keep it extended. Clothed with this aerial mantle, which to the spectator seems formed of resplendent quicksilver, she plunges to the bottom, and, with as much dexterity as a chemist transfers gas with a gasholder, introduces her bubble of air beneath the roof prepared for its reception. This manœuvre she repeats ten or twelve times, until at length, in about a quarter of an hour, she has transported as much air as suffices to expand her apartment to its intended extent, and now finds herself in possession of a little aerial edifice—I had almost said an enchanted palace—affording her a commodious and dry retreat in the very midst of the water. Here she reposes unmoved by the storms that agitate the surface of the pool, and devours her prey at ease and in safety. Both sexes form these lodgings. At a particular season of the year the male quits his apartment, approaches that of the female, enters it, and enlarging it by the bubble of air that he carries with him, it becomes a common abode for the happy pair.[1] The spider which forms these singular habitations is one of the largest European species, and in some countries not uncommon in stagnant pools."[2]

Tribe II.—Inæquitelæ.

External spinners conical, convergent, slightly projecting, disposed *en rosette*. Legs slender, first and last pair usually the longest. The maxillæ are inclined on the tongue, and are either narrow or present no sensible enlargement at their superior extremity. The abdomen is more voluminous, softer, and more highly coloured than in the preceding tribe. Their webs constitute an irregular net-work of various forms, the threads of which cross each other in different directions. They bind their prey with cords, which, though silken, secure them very effectually. The species are short-lived, and tend their eggs very carefully till the exclusion of the young.

Genus Scytodes, Latr.—Eyes six, disposed in pairs. M. Dufour states that the crotchets of the tarsi are inserted in a supplementary article.

Sp. Thoracica. (See Plate L.)—Pale reddish-white, spotted with black. Thorax large, somewhat orbicular. Abdomen not globose.

This species inhabits houses. It has been found near Dover, but is otherwise scarcely known as a British species.

Genus Theridion, Walck.—Eyes eight in number, of which four in the centre form a square, the two anterior being placed upon a small eminence, and a pair are placed on each side upon a common elevation. The thorax is almost triangular, or shaped like a heart reversed.

Sp. Malmignatto. Aranea 13-*guttata*, Fab.—Lateral eyes, separated from each other. Body black, with thirteen small round spots of a blood-red colour on the abdomen. This species inhabits Corsica, the inhabitants of which island hold it in great dread, from the belief that its bite is dangerous, if not mortal.

Another species, the *Theridion benignum* of Walckenaer, may from its name be presumed to possess another character. It lives in autumn among the clusters of grapes, where it watches for its prey, and thus deters many insects from injuring the fruit. The prejudice against this genus probably arises from several of them being of a dark colour, with red spots resembling drops of blood upon their bodies.

Genus Episinus, Walck.—Eyes eight, near each other, and placed upon a common elevation. The thorax narrow and almost cylindrical.

Sp. Truncatus.—Thorax acute in front, rather longer than broad, obscure brown above, reddish brown beneath. Abdomen pyramidal, truncated behind, its anterior portion brown, third pair of legs whitish, the others brown.

Genus Pholcus, Walck.—Eyes eight, tuberculated, divided into three groups, of which there is one on each side composed of three eyes disposed in a triangle, and a third in the centre, somewhat advanced, composed of two eyes on a transverse line.

Sp. Phalangioides, Walck. *Araignée domestique à longues pattes*, Geoff.—Body long, narrow, pubescent, of a livid or pale yellow colour. The abdomen is almost cylindrical, very soft, and spotted above with black. The legs are very long and slender, with whitish rings at the extremities of the thighs and tibiæ.

This species is common in houses in the western parts of England. Its body vibrates like that of some tipulæ. The female carries her eggs in an agglutinated mass between her mandibles.

Tribe III.—Orbitelæ.

In this tribe the exterior spinners and the legs resemble those of the preceding, but the maxillæ differ, being straight, and sensibly broader at their extremity. The first and second pair of legs are the longest. The eyes are eight in number, of which four are placed quadrangularly in the centre, and a pair on each side. These spiders differ from the *Inæquitelæ* in the form of their webs, which are composed of a regular net-work, formed of concentric circles, crossed by straight lines or radii, proceeding from the centre, where the animal lies, to the circumference. Some conceal themselves in cavities, or in chambers built by themselves, near the margins of their webs, which are sometimes horizontal, sometimes perpendicular. Their eyes are numerous, agglutinated, and inclosed in a large cocoon.

Genus Linyphia, Latr.—Four central eyes, of which the posterior pair are larger, and separated by a larger space; the others are in pairs, one on each side, and placed obliquely. The maxillæ are enlarged at their superior extremity.

This genus constructs among brooms and other bushes a slender, open, horizontal net, from which various threads proceed irregularly upwards to different points.

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[1] *Mémoire pour servir à commencer l'Histoire des Araignées Aquatiques.*
[2] *Introduction to Entomology*, by Kirby and Spence, vol. i. p. 469.

Sp. Triangularis.—Pale red, inclining to yellow. Thorax with a dark dorsal line, bifid in front. Abdomen oval, inclining to globose, with spots and angulated bands of brown and white. Inhabits the European hedges, and constructs its webs on brooms and pine-trees.

Genus Uloborus, Latr.—Four posterior eyes placed at equal distances on a straight line, and the two lateral eyes of the first line nearer the anterior margin of the thorax than the intermediate pair, so as to form an arch bent backwards. The maxillæ commence in this genus to enlarge a little above their base, and terminate in the form of a spatula. The tarsi of the last three pair of legs are terminated by a single claw. The first article of the two posterior pair have a range of small hairs.

These spiders repose in the centre of their webs, with their four anterior feet stretched forwards; the third pair are extended laterally, and the posterior pair backwards.

Sp. Walckenarius, Latr.—Of a reddish-yellow colour, covered by a silky down, forming on the upper part of the abdomen two series of small bundles. Length about five lines. The legs are marked with paler rings. Occurs near Bordeaux, and other southern departments of France.

Genus Tetragnatha, Latr.—Eyes placed four and four on two nearly parallel lines, and separated by almost equal intervals. Maxillæ long, narrow, enlarged only at their superior extremity. Mandibles also very long, especially in the males. Their web is vertical.

Sp. Extensa.—Abdomen oblong, golden green, with the sides and two lower lines yellowish. Sits with its legs extended on a vertical web. Inhabits moist places.

Genus Epeira, Walck.—A pair of eyes on each side, almost contiguous; the other four forming a central quadrangle. The maxillæ dilated from their base.

With the exception of that of *E. curcubitina*, which is horizontal, the webs of this genus are either vertical or inclined. Some repose in the centre of their webs, with their bodies reversed, or heads downwards; others construct a sheltering habitation, sometimes formed of leaves spun together, sometimes like a silken tube, or of a more open form like a bird's nest, in the vicinity of their nets. Some foreign species construct such powerful webs as to arrest the flight of small birds, and even to incommode the traveller while journeying through the forests. Many of the species are remarkable for the beauty of their colours, their singular forms, and still more singular habits. Between 60 and 70 species are described by M. Walckenaer in his *Tableau des Aranéides;* and M. Leon Dufour has greatly contributed to illustrate the history of this extensive genus in the *Annales des Sciences Physiques* of Brussels, and the *Annales des Sciences Naturelles* of Paris. We regret that the limits of our present undertaking do not admit of our entering into further details.

Sp. Diadema. (See Plate L.)—Reddish; abdomen globose-oval, with an elevated angle on each side near the base; dorsal band darker, broad, triangular, dentated, with a triple cross of yellowish-white spots, and four impressed dots disposed in a quadrangle. Legs and palpi spotted with black.

This is one of the largest of the British species. It frequents the borders of woods, rocks, and gardens; also moors and other desert places. It varies considerably both in size and colour. We are indebted to Treviranus for an account of its anatomical structure. The heart presents a character not observed in that of any other species. From its inferior and anterior part proceed two muscles, which, at first united in one, diverge as they approach the posterior portion of the abdomen. The heart itself exhibits several branches, the two anterior of which are sent to the branchia; and the function of these last-named organs, according to Treviranus, is to absorb humidity from the atmosphere, and convey it to the circulating system. The true respiratory organs are discoverable in a species of stigmata placed in the thorax and abdomen. These stigmata are not pierced, like those of insects; but numerous vessels are seen distributed over their surface.

The sceptre or diadem spider, as this species is frequently called, pairs about the end of summer, and deposits its eggs in autumn. The eggs are of a fine yellow, inclosed in a cocoon of a close texture, but covered with a looser substance of a yellowish hue. This spider forms no nest, but shelters itself beneath a leaf or some other natural covering. Its web is large and vertical. The young are hatched in spring, and are at first yellow, with a blackish spot on the upper part of the abdomen.

M. Vautier has described a singular species of this genus, remarkable for the posterior enlargement of its abdomen, which is terminated by a couple of arched and elongated spines. (*Annales des Sciences Naturelles*, tome i. p. 261.) It is named *Epeira curvicauda.* (See Plate L.)

Tribe IV.—Laterigradæ.

The species which constitute this tribe are, like those of the preceding, of sedentary habits; but they differ in their mode of progression, being able to walk sideways and backwards, as well as straight forward like the others. Hence the designation of the tribe. Their four anterior feet are always longer than the others. In some the first pair are longer than the second; in others they are nearly equal. The mandibles are usually small, with their crotchets transversely folded, as in the preceding tribes. The eyes are always eight in number, frequently unequal, and forming by their union a crescent, or the segment of a circle. The maxillæ in the generality of this species are inclined upon the lip. The body is generally flattish, crab-shaped, with the abdomen large, rounded, and triangular.

The genera included in this division can scarcely be said to spin webs,—they merely throw out a few isolated threads. They are usually found on plants, tranquil and stationary; sometimes concealed between two leaves, of which they fasten the edges together. They watch their eggs with great care till the young are hatched.

Genus Micrommata. Sparassus, Walck.—Maxillæ straight, parallel, rounded on their edges. Eyes disposed four and four, on two transverse lines, of which the posterior is the longer, and arched backwards. The second and first pair of feet are the longest. The languette is semicircular.

Sp. Smaragdina.—Colour bright green, sides bordered with yellow. Abdomen greenish-yellow, with a darker green line upon the back.

This species places its cocoon in the centre of three or four leaves fastened together and lined with silk.

Genus Senelops, Dufour.—Maxillæ straight, or slightly inclined, without lateral sinus, pointed, and obliquely truncated on the internal side. Languette semicircular. Six eyes in front, on a transverse line; two others behind, one on each side. The legs are long; the first pair are the shortest.

Sp. Omalosoma.—Four lines in length, very flat, of a reddish-gray colour, with cinereous spots, and the feet ringed with black. The abdomen appears to present

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posteriorly the vestige of rings or segments, forming a sort of dentation along the sides.

This rare species was discovered by M. Dufour in the kingdom of Valentia. It inhabits rocks, and runs with singular rapidity. It occurs both in Egypt and Syria.

Genus Philodromus, Walck.—Maxillæ inclined upon the languette, which is higher than broad. The eyes, nearly equal in size, are disposed in the form of a cross or semicircle. The mandibles are lengthened and cylindrical.

Sp. Tigrina.—Thorax very broad, flattened, of a reddish fawn-colour, brown laterally and posteriorly, white in front. The pentagonal abdomen variously coloured by means of minute red, brown, and white hairs, by which it is covered. It is bordered with brown along the sides, and is marked on the dorsal region with from four to six impressed points. The belly is whitish. The legs are long, slender, reddish, with brown spots.

This species is common on trees. When touched it immediately either runs off with great rapidity, or suddenly drops to the ground. Its cocoon, of a beautiful white colour, incloses about one hundred unagglutinated eggs. It places them in the clefts of trees, and guards them with great care.

Genus Thomisus, Walck.—Mandibles shorter than in the preceding genus, wedge-shaped. Four posterior feet, shorter than the others. The sexes frequently differ in their size and colours.

Sp. Citreus.—Colour citron-yellow. The abdomen large, broader behind; the back with two red spots. Inhabits flowers. The female is common in Britain; the male more rare, of a smaller size, brown, banded with yellowish-green.

B. Erraticæ.

The four preceding tribes are characterized by their usually sedentary habits. The remainder of the Araneides are of a more wandering disposition. This is in proper accordance with their other capabilities; for, as they cannot spin webs for the capture of their prey, they are under the necessity of moving about from place to place to extend the sphere of those exertions, the successful issue of which depends on agility as well as cunning. "Such," says Evelyn, "I did frequently observe at Rome, which, espying a fly at three or four yards distance, upon the balcony where I stood, would not make directly to her, but crawl under the rail, till, being arrived to the antipodes, it would steal up, seldom missing its aim; but if it chanced to want anything of being perfectly opposite, would, at first peep, immediately slide down again,—till, taking better notice, it would come the next time exactly upon the fly's back; but if this happened not to be within a competent leap, then would this insect move so softly, as the very shadow of the gnomon seemed not to be more imperceptible, unless the fly moved; and then would the spider move also in the same proportion, keeping that just time with her motion, as if the same soul had animated both these little bodies; and whether it were forwards, backwards, or to either side, without at all turning her body, like a well-managed horse; but if the capricious fly took wing and pitched upon another place behind our huntress, then would the spider whirl its body so nimbly about, as nothing could be imagined more swift; by which means she always kept the head towards her prey, though, to appearance, as immovable as if it had been a nail driven into the wood, till by that indiscernible progress (being arrived within the sphere of her reach) she made a fatal leap swift as lightning upon the fly, catching him in the pole, where she never quitted hold till her belly was full, and then carried the remainder home."[1]

Though the species above alluded to, and others constituting the ensuing tribes, spin no webs, they are yet provided with a sufficiency of the necessary material to enable them to construct cocoons for their eggs, and also to throw out an occasional thread to break their fall when leaping on a vertical surface.

The eyes of the erratic spiders are always eight in number, and are grouped rather along than across the thorax, forming a curvilinear triangle, or a truncated or quadrilateral oval. One or two pair of eyes are generally much larger than the others. The thorax is large, and the legs robust.

Tribe V.—Citigradæ.

In this tribe the legs are generally fitted for running. The maxillæ are always straight, and rounded at their extremities. The eyes are grouped in a curvilinear triangle, or in an oval or oblong figure, of which the anterior side is much narrower than the thorax taken in its greatest breadth. The thorax itself is ovoid, narrower in front, and somewhat ridged or keel-shaped in its longitudinal centre.

The females for the most part keep close to their cocoons, which they carry about them, either suspended at their extremities, or applied between the chest and the base of the abdomen. They watch over their young for some time after they are hatched.

Genus Oxyopus, Latr. Sphasus, Walck.—Eyes ranged two and two on four transverse lines, of which the two at the extremes are the shortest; they describe a kind of oval figure, truncated at each end. The languette is elongated, narrow at the base, dilated and rounded at the extremity. The first pair of legs is the longest; the fourth and second are nearly equal; the third is the shortest.

Sp. Variegatus.—Body hairy and gray, variegated with red and white. Legs pale reddish, spotted with brown; the tibial *spines* elongate. Inhabits France.

Sp. Lineatus. (See Plate L.) Abdomen elongated, yellowish, with lengthened black spots on the sides, and a black longitudinal band beneath. This species forms its web on low growing plants, but nestles among the leaves of trees about the period of laying.

Genus Ctenus, Walck.—Eyes placed on three transverse lines (2, 4, 2) forming a curvilinear triangle, reversed, and truncated anteriorly. The languette is square and almost isometric. The fourth pair of feet are the longest; the first pair are next in length; the third are the shortest.

This genus, according to Latreille, was established for the reception of a species found in Cayenne. Others, possessed of the same generic characters, have been found both in that colony and in Brazil, but their descriptions have not yet been made public.

Genus Dolomedes, Latr.—Eyes disposed on three transverse lines (4, 2, 2,) representing a quadrilateral figure, somewhat broader than long. The two posterior are

[1] Evelyn's *Travels in Italy.*

placed upon an eminence. The second pair of legs are equal to the first, if not somewhat longer; and the fourth pair are the longest of all. The languette is square, and, like that of the preceding genus, is as broad as high.

Of this genus, some have the two exterior eyes of the anterior line larger than the pair comprised between them; and the form of the abdomen is oblong oval, with a terminal point. The females construct a silken nest, funnel-shaped, or in the form of a bell, which they place in a thicket, or among leaves near the summit of a tree. In this they deposit their cocoons of eggs, of which they are exceedingly careful. When they leave their retreats, either to hunt for prey, or from any cause of alarm nearer home, they never fail to carry their bundle of eggs along with them. Clerk (*Aranei suecicæ*) mentions his having observed species of this genus spring with great activity upon flying insects.

Other species of Dolomedes have the four anterior eyes of equal size, and the abdomen oval, and rounded at the extremity. These inhabit the margins of water, run over the surface with agility, and even proceed a little beneath the surface without being wetted. The females form coarse irregular nets, suspended between the branches of plants, and place their cocoons upon them.

Sp. Mirabilis. Aranea saccata, Linn.—Colour pale reddish, covered with grayish down. Thorax heart-shaped, anteriorly abruptly sloping; the anterior angles and dorsal line whitish. Abdomen conical, suboval; darker on the back. Inhabits the woods of Europe. The female carries about her eggs inclosed in a dirty orange-coloured or whitish bag.

Genus Lycosa, Latr.—Eyes disposed in a quadrilateral figure, longer than broad, the posterior pair not placed on an eminence. The first pair of feet are sensibly longer than the second, but shorter than the fourth, which are the longest of all. The maxillæ are truncated obliquely at their external extremity. The languette is square, but rather longer than broad.

The species of this genus run swiftly on the ground. They live in holes, either previously formed by the accidents of nature, or hollowed out by themselves, and fortified along their interior walls by silken threads. Some dwell in the cavities of walls, where they form silken tunnels, covered externally by minute particles of earth and sand. In these retreats they undergo the periodical renewal of their skins; and also pass the winter, after having previously closed up the outer orifice of their dwellings. The females likewise deposit their eggs in these elongated cells. Their cocoons are usually fixed to the extremity of the abdomen, and when the mothers go abroad, they have thus no difficulty in carrying their eggs along with them. As soon as the young are hatched, they collect on the back of the female parent, and remain there till they gain sufficient strength to shift for themselves. The species are exceedingly voracious, and defend the possession of their domiciles with the greatest courage.

Sp. Tarentula. Aranea tarentula, Linn. (See Plate L.)—Colour ashy brown above; thorax with a radiated line, and margins griseous; abdomen marked anteriorly with trigonal spots, posteriorly with arcuate transverse streaks of black, bordered with white; beneath saffron-coloured, with a transverse black band; thighs and tibiæ beneath rufous white, with two black spots.

This species, an inhabitant of the south of Europe, is the celebrated tarentula, of which so many extraordinary accounts have been given by travellers. It is scarcely necessary to observe that these are fabulous. Its bite was said to produce symptoms equally severe with those of the most malignant fever, and of such a nature as to admit of being cured only by means of music. Some authors have even given a list of the tunes which are most efficacious in restoring the *tarentolati* (for so the patients were called) to health. The true tarentula occurs in the south of Italy, especially near the town of Tarentum, from which it has no doubt derived its name. It is the largest of the European species.

A species of this genus exists in the south of France, which bears a close resemblance to the Italian species, and appears to have been confounded with it by Olivier. It is the *Lycosa Melanogaster* of Latreille, and the *Tarentula Narbonensis* of Walckenaer, and differs from the species above described chiefly in being somewhat less, and in having the abdomen black beneath, and the edges only of a red colour.

Genus Myrmecia, Latr.—Eyes placed on three transverse lines; four in front, then two somewhat nearer the centre than the outer eyes of the first line, and two others behind the preceding pair. The mandibles are strong. The maxillæ are rounded and hairy at the extremity. The tongue is almost square, somewhat longer than broad. The feet are long, almost filiform, the fourth and first pair being the longest. The thorax appears as if divided into three portions, of which the anterior is the largest, and of a square form; and the others are hunched or knot-shaped. The abdomen is much shorter than the thorax, and is covered from its origin as far as the middle by a solid epidermis.

Sp. Rufa.—Length about six lines. Fulvous, shining, nearly smooth, with the extremities of the palpi, the thighs, the first article of the posterior feet, and the end of the abdomen, blackish. Found near Rio Janeiro.

Tribe VI.—Saltigradæ.

In this group the eyes are placed in a square figure, of which the anterior line extends along the breadth of the thorax. The thorax is demi-ovoid, or nearly square; flat, or but slightly bulged above; as broad before as elsewhere, and sloping suddenly down the sides. The legs are adapted both to running and leaping, and the thighs of the anterior pair are generally remarkably large and strong.

Several of the species construct among leaves and stones small oval sacks of silk, open at both ends, in which they seek refuge during bad weather, and while changing their skins. When any danger threatens these retreats they appear on the outside, and after a moment's reconnoitring run off with great agility. The females form small tents, which afterwards serve as cradles for their young, and where the mother and her progeny dwell for some time together. The males, in their battles with each other, exhibit many singular manœuvres.

The genus *Tessarops* of M. Rafinesque, and that of *Palpimanus* established by M. Dufour, both belong to this tribe. That first mentioned is said to have only four eyes. The latter is very rare, and was discovered in Valentia. We are not yet acquainted with the characters of either.

Genus Eresus, Walck.—Four eyes approached in a small trapezium, near the centre of the anterior portion of the thorax; and four others on its sides, forming a larger square. The languette is pointed and triangular. The tarsi are terminated by three crotchets.

Sp. Moniligerus.—Black; abdomen above cinnabar-coloured, with four or six black dots, arranged in two longitudinal lines; joints of the legs whitish; hinder sides of the thorax, the thighs, and the first joint of the four hinder legs, pale cinnabar. This is the *Aranea quadrigut-*

Arachnides.

tata of Rossi's *Fauna Etrusca.* It inhabits France, Germany, and England.

Genus Salticus, Latr. Attus, Walck.—Four eyes on a transverse line on the anterior portion of the thorax, the two intermediate larger than the others; the remaining eyes are placed two and two on each side of the thorax; they thus form a kind of parabola or part of a square, open posteriorly. The languette is very obtuse, and truncated at the summit. The tarsi have only two crotchets at their extremity. The mandibles of many of the males are very large. The shape of the thorax and the length and proportions of the legs vary according to the species.

Sp. Scenicus. Aranea scenica, Linn.—Black, margin of the thorax covered with white down; abdomen short ovate, covered above by a reddish white pubescence, with three transverse arcuate lines, and the termination white; the first band is basal and entire, the others acutely bent anteriorly, and interrupted in the middle.

This species is called in Britain the hunting spider. It occurs on walls and palings, and is a common species, of considerable beauty. It loves exposure to light and heat, and is frequently seen near windows in sunny weather. Its movements are lively and amusing. When it sees a fly or a gnat it moves towards it with a slow and gentle motion, and then springs upon it with a single rapid bound. It leaps upon its prey as securely down a perpendicular wall as on a horizontal surface, by means of a thread which, previous to each of its bounds, it has the precaution to attach to the plane of its position. The palpi of the female are whitish; her legs reddish-gray, with darker spots. The mandibles of the male are very large.

Family II.—Pedipalpi.

Palpi very large, extended in the form of arms, and terminated either by pincers or a claw. Mandibles with two fingers, of which one is movable. Abdomen composed of distinct segments, without any terminal spinners. Sexual organs at the base of the abdomen. Thorax consisting of a single piece, and presenting near its anterior angles three or two eyes, approached or in groups, and two other eyes close together in the centre of its anterior or posterior margin. Four or eight pulmonary sacks.

Tribe I.—Tarentulæ.

Our present division corresponds to the genus tarentula of Fabricius. The abdomen is attached to the thorax by a pedicle, or by a portion of the transverse diameter, without comb-shaped plates at its inferior base, or sting at its extremity. The stigmata are four in number, placed near the base of the abdomen, and covered by a plaque. The mandibles are terminated merely by a claw or movable crotchet. The languette is elongated, narrow, dart-shaped, concealed. Maxillæ two, formed by the first joint of the palpi. Eyes eight, of which three are disposed in the form of a triangle near each anterior corner, and two are placed upon a tubercle near the centre of the anterior margin.

Naturalists have as yet acquired but a slight knowledge of this tribe of Arachnides. They inhabit chiefly the warmest countries of Asia and America.

Genus Phrynus, Olivier.—Palpi terminating in a claw. Body flat, thorax broad, crescent-shaped. Abdomen without a tail. The two anterior tarsi long, slender, antenniform.

This genus was named Tarentula by Fabricius, but we prefer retaining the name previously bestowed by Olivier, not only on account of its possessing a prior claim, but because the term Tarentula, as generally understood, applies to a spider of the genus *Lycosa,* the *Aranea tarentula* of Linnæus.

Sp. Lunatus. (See Plate L.)—The arms or foot-palpi of this species are nearly three times the length of the body. They are unfurnished with spines, except at the extremity of the fourth article. This is the *phalangium lunatum* of Pallas. *Spicil. Zool.* fasc. 9. tab. fig. 5, 6.

Sp. Reniformis. Phalangium reniforme, Linn. Herbst. *Tarentula reniformis,* Fabr. (See Plate L.)—Arms very spiny on their interior margins; the third and fourth articulations elongated. The fifth articulation is furnished with four spines. According to Maugé this species is much dreaded by the negroes of the Antilles.

Genus Thelyphonus, Latr.—Palpi shorter and thicker than those of the preceding genus, terminated by pincers or double fingers. Body long, thorax oval, abdomen furnished with a slender articulated prolongation or tail. The anterior tarsi are short, with few articulations.

This genus appears to have been confounded by Gronovius with *Scorpio,* by Linnæus with *Phalangium,* and by Fabricius with *Tarentula.* It forms the passage in the natural progress of generic forms to the scorpion tribe.

Sp. Caudatus, Latr. *Phalangium caudatum,* Linn. (See Plate L.)—Some confusion seems to exist in regard to the exact or characteristic locality of this species. It is now said to occur in Java. South America furnishes another species, called by the inhabitants of Martinique *vinaigrier,* on account of its extremely acid odour.

Tribe II.—Scorpionides.

Abdomen sessile, or united to the thorax by its entire breadth, and furnished at its lower base with two movable comb-shaped plates, and terminated by a knotted base, armed with a sting at its extremity. Stigmata eight in number, four on each side along the belly. Mandibles terminated by two fingers, of which the exterior is movable.

The thorax of scorpions assumes the form of a lengthened square. There is a triangular appendage at the base of each of the four anterior feet, which in combination produce the appearance of a lip of four divisions; but of these, according to the views of Latreille, the lateral pair ought to be regarded as maxillæ, and the two others as forming the languette. The abdomen is composed of twelve articulations, including those of the tail, which are six in number. The first division of the abdomen is composed of two parts, the anterior of which bears the sexual organs, the posterior the comb-shaped appendages. These last-named parts are composed of a principal portion, narrow, lengthened, jointed, movable at its base, and furnished along its inferior side with a range of small, narrow, elongated, parallel plates, hollowed interiorly, united to the principal piece before mentioned, and somewhat resembling the teeth of a comb; their number seems to vary according to the species, and probably even with the age of the individual. The uses of these organs in the economy of the animal have not yet been determined. The four following segments of the abdomen have each a pair of pulmonary sacks and stigmata. Immediately behind the sixth segment the abdomen becomes suddenly narrow, and the six following knotty rings compose the tail, terminated by an arched slender point, beneath the extremity of which are two small holes, from which, at

the will of the animal, there flows a poisonous fluid, contained in an interior reservoir. The tarsi resemble each other, and are composed of three articulations, the last of which is armed with a pair of crotchets. The four posterior legs have a common base, and the first article of the haunches is as it were soldered; the posterior pair are in part joined by their back part to the abdomen.

Two nervous cords, which derive their origin from the brain or superior ganglion, unite at intervals and form seven other ganglia, of which the last belongs to the tail. In all other Arachnides, according to Latreille, the number of these ganglia never exceeds three.

Eight stigmata mark the position of an equal number of whitish purses, containing a great number of small delicate plates, among which it is believed the air permeates. A muscular vessel prevails along the back, and communicates by means of two other vessels with each of these purses. The intestinal canal is straight and slender. The liver is composed of four pair of glandular bunches, which discharge their fluid into the intestines at four points. The females are viviparous.

Scorpions occur in the warmer regions of Europe, Asia, Africa, and America. Several of the larger exotic species are poisonous, but the bite of the European kinds is rarely attended by fatal consequences, except to small animals. Maupertuis tried various experiments upon dogs and poultry with the scorpions of Languedoc. Only one dog died. The others, as well as the poultry, though repeatedly stung by *exasperated* scorpions, suffered no injury. Redi's experiments on pigeons were followed by a different result. They generally died in convulsions in about five hours after the infliction of the wound. Some, however, appeared to suffer no inconvenience from the bite of these animals. This difference may be attributed to the particular condition, or rather the quantity of the poison contained in the vessels at the time of the trial. The scorpions of Tuscany are so harmless that they are handled by the peasants without any fear.

Scorpions generally inhabit sombre and shady places, under stones, among old ruins, deserted dwelling-houses, and even, though more rarely, such as are occupied by man. They prey upon various kinds of insects, which they sting with their envenomed tails. They are very fond of the eggs of spiders and of insects. In running, they usually carry their tails curved forwards over their backs; and they possess the power of moving them in all directions, either as offensive or defensive weapons. We have already mentioned that they produce their young alive. Redi states the number of these to amount to between 26 and 40, but some species are more prolific. Maupertuis found from 27 to 65 in the bodies of those which he examined. They were suspended or connected by a lengthened thread, and each was inclosed in a very delicate membrane. The European kinds appear to produce in August, and are afterwards observed to change their skins. Some naturalists are of opinion that they couple twice a year. The female carries her young for several days upon her back, and watches over and defends them for about a month.

In the preceding generalities we have given the principal characters of the old genus scorpio. That genus has been recently divided into two, in conformity with the number of the eyes.

Genus Scorpio, Latr.—Eyes six.

Sp. Europæus.—Colour brown, varying in shade. Feet and terminal joint of the tail of a paler yellowish brown. Claws angular and heart-shaped. Pectens, or comb-shaped appendages, each with nine teeth.

The characters given by Linnæus to his S. Europæus do not accord with our observations on those found in France and Italy. "Cauda sub aculeo mucronata est." An American species is furnished with a projecting point *beneath the sting*, and the existence of that feature in the Transatlantic species seems to have induced De Geer to mistake the latter for the one described by Linnæus as inhabiting the southern countries of Europe.

Genus Buthus, Leach.—Eyes eight.

Sp. Occitanus. (See Plate L.)—Colour yellowish or reddish. Tail rather longer than the body, with elevated and delicately granulated lines. Each pecten furnished with 28 teeth or upwards. About two inches in length.

This is the species experimented on by Maupertuis. He inclosed about 100 in one place, and after the lapse of a few days he found only 14 survivors, which had killed and eaten their companions. It occurs in France, Portugal, and Spain; likewise in Barbary.

Sp. Afer. (See Plate L.)—Nearly half a foot long, and of a blackish brown colour, with large heart-shaped claws, chagrined on their surface, and slightly haired. A notch in the anterior angle of the thorax. Number of teeth in each comb, thirteen. Occurs both in Africa and India.

Sp. Americanus.—Body slender, elongated, yellowish, with brown spots. Combs with twenty-eight teeth. Arms long and thin; claws filiform. Tail three times the length of the body. Sting with a point beneath. Inhabits America.

The *Scorpio dentatus* of Herbst is allied to the preceding. It inhabits Sierra Leone.

Order II.—Trachearia.

The Tracheal Arachnides are distinguished by their respiratory organs, which consist of radiated or branched tracheæ, receiving air only by two stigmatic openings. They possess no (ascertained) circulating system, and their eyes vary from two to four. Müller assigns six eyes to the *Hydrachna umbrata*, but Latreille is of opinion that some optical or other deception may have interfered with the usual accuracy of the great Danish naturalist. The respiration of the Pycnogonides is unknown, no stigmata having been observed in that family.

The Arachnides of this order are the smallest of their class. Some species are almost microscopical. They are naturally divided into two great divisions. Those which belong to the first are more nearly allied to the preceding order, the pulmonary Arachnides, in the form and structure of their masticating organs; such as pertain to the second have the parts of the mouth more simply constructed of certain parts, which, in union with the languette, constitute a kind of trunk or sucker. But many of the species are so minute, even in their general dimensions, that the examination of these organs, and the consequent classification of the species in accordance with a *cibarian* system, are attended with considerable difficulty, and, in the opinion of Latreille, ought not to be had recourse to, except in default of other more obvious characteristics.

The long-legged spider (commonly so called), which is a species of *Phalangium*, frequently met with in hay fields and other places during the summer season, is a familiar example of this order. So also are mites and other acarideous species.

Family I.—Pseudo-Scorpiones.

Thorax articulated, the anterior segment the larger. Abdomen distinct and annulated. Palpi large, in the form of feet or claws. Both sexes with eight feet, having two equal hooks at the end of the tarsi, the two anterior

sometimes excepted. Two mandibles (*antenne-pinces* or *chelicères* of Latreille) terminated by a couple of fingers; and two maxillæ formed by the first article of the palpi. This family consists of two genera, the habits of which are terrestrial; their bodies oval or oblong.

Genus Galeodes, Oliv. Solpuga, Lichtenstein.

Mandibles very large, with vertical, strongly toothed fingers, of which one is superior, fixed, frequently furnished at its base with a slender pointed appendage; the other movable. Palpi large, advanced, in the form of feet or of antennæ, terminated by a short button-shaped article, vesicular and hookless. Anterior pair of feet resembling the palpi, but smaller; they are also hookless. Each of the other feet has the terminal joint of the tarsus furnished with a pair of hooks. The posterior pair of feet have five remarkable scaly excrescences placed upon foot-stalks, and ranged along the inferior surface of their first two articulations. The eyes, two in number, are very close to each other, and are situated on an eminence of the anterior portion of the first segment of the thorax, which presents the appearance of a large head bearing the anterior pair of feet, in addition to the masticating organs.

According to M. Dufour the terminal article of the palpi incloses a particular disc-shaped organ, of a whitish colour and pearly lustre, not visible externally unless the animal is irritated. The lip (*labre*) has the form of a small beak, much compressed, recurved, pointed, and hairy. The languette is small, keel-shaped, and terminates in two divergent threads, each placed on a small articulation. Latreille perceived a pretty large stigmatic opening on each side of the body, between the first and second feet, and another cleft at the base of the abdomen. The abdomen is oval and composed of nine rings. We lately received two species of this genus from Persia.

Sp. Araneoides, Olivier. (See Plate LI.) *Solpuga Arachnoides*, Herbst.—Colour pale yellowish-brown. Inhabits Africa and the western countries of Asia.

Genus Chelifer, Geoff. Obisium, Illiger. — Palpi elongated, furnished with didactile pincers at their extremity. Eyes placed on the sides of the thorax. Legs nearly equal in size, each terminated by a pair of crotchets. Body flat. Thorax almost square.

These animals run swiftly, both backwards and forwards. They carry their eggs about with them after the manner of spiders. The elder Hermann is of opinion that they spin webs. Such of the species as have the thorax divided or impressed by a transverse line form the genus Chelifer of Dr Leach. Their eyes are two in number. Others have the thorax undivided, and of these the eyes amount to four. They form the genus Obisium of the last-named author.

Sp. Fasciatus.—Hands oval. Segments of the abdomen bordered with white. Lives beneath the bark of willow and other trees. Sometimes occurs near London. Leach, in *Linn. Trans.* xi.

Sp. Cancroides. (See Plate LI.)—This species measures about a line and a half in length. The body and legs are of a reddish brown. The palpi are about twice the length of the body. It is a European species, inhabiting old books, herbariums, &c. and preys upon the bodies of several destructive insects. It ought therefore to be cherished in the live state by collectors.

Family II.—Pycnogonides.

Trunk composed of four segments, occupying almost the entire length of the body, terminated at each extremity by a tubular article, of which the anterior portion, sometimes simple, sometimes accompanied by mandibles (*antenne-pinces*) and palpi, or by one or other of these organs, constitutes the mouth. Both sexes have eight feet proper for running; but the females are moreover provided with two false feet, placed near the anterior pair, and serving to carry the eggs.

The species of which this family is composed inhabit the sea. They usually keep themselves concealed among sea-weed along the shores, and feed upon small marine animals. Their movements are slow. Their bodies are generally linear, the legs very long, composed of from eight to nine articles, and terminated by two unequal crotchets, of which the smaller is cleft. The first articulation of the body, or that which represents the head and mouth, forms an advanced, nearly cylindrical tube, pierced at its extremity by a triangular opening. It also bears the mandibles and palpi. The former are linear or cylindrical, composed of two pieces, of which the last is pincer-shaped, with the inferior or fixed claw shorter than the other. The palpi are filiform, with a crotchet at the end, and composed of from five to nine articles. Each of the succeeding segments of the body, with the exception of the last, serves as a point of attachment to a pair of legs; and the segment which articulates with the mouth is provided on its dorsal portion with a tubercle bearing the eyes, and on its ventral portion (in the females) with a small additional pair of feet on which the eggs are distributed. The terminal segment is small, cylindrical, and pierced at its extremity. The stigmatic openings in the bodies of this family have not yet been discovered.[1]

M. Savigny is of opinion that this family forms the natural transition from the class Arachnides to the crustaceous tribes, and great uncertainty still prevails in the minds of naturalists regarding their true position in the system. We place them in the position which they now occupy in our present arrangement, in accordance with the views of M. Latreille. M. Milne Edwards, who has studied these animals in their native places, informed that celebrated entomologist, that in the interior of the Pycnogonides he observed cæca or lateral expansions of the intestinal canal.

Genus Pycnogonum, Brunnich.—In this genus the mandibles and palpi are wanting, and the length of the feet scarcely exceeds that of the body, which is proportionally short and thick. The species are parasitical on cetaceous animals.

Sp. Balænarum. (See Plate LI.) *Phalangium Balænarum*, Linn.—Inhabits the European Ocean. This species is frequently taken by the trawl-fishers in Plymouth Sound. It has been found by M. d'Orbigny on the coasts of France.

Genus Phoxichilus, Latr.—In this genus the palpi are wanting, as in the preceding; but we observe a pair of mandibles, and a greater elongation of the legs.

To this genus belong *Pycnogonum spinipes* of the *Fauna Groenlandica*, *Phalangium hirsutum* of Montagu (*Linn. Trans.* ix.), *Nymphon hirtum* of Fabricius, &c.

Genus Nymphon, Fab.—Resembles the preceding genus

[1] Recent observations induce the belief that these creatures breathe through their skins,—a peculiar character, which, when satisfactorily established, may lead to their being erected into a separate order, intermediate in some respects between the Arachnides and the apterous insects of the parasitical order. (See *Règne Animal*, tome iv. p. 277, *note.*)

in the narrow and oblong form of its body, the length of its legs, and the presence of mandibles; but in addition to these organs there are likewise a pair of palpi.

Sp. Gracile, Leach. (*Zool. Misc.* i. 45.)—Colour cinereous; thighs cylindrical. Inhabits most parts of the British seas. We are doubtful whether this species should be considered as synonymous with the *Nymphon grossipes* (*Phalangium grossipes*, Linn.) figured on Plate LI. The term *grossipes* is certainly very inapplicable to either kind.

Genus Ammothea, Leach.—Mandibles much shorter than the rostrum, with equal joints, the fingers arcuate, and meeting at their tips. Palpi nine jointed, the third joint very long. Legs slender; coxæ with the middle joint longest; tibiæ with the first joint rather the shortest; tarsi with the first joint small; claws double, unequal. Egg-bearing organs nine-jointed, inserted under the first legs, behind the rostrum.

Sp. Carolinensis. (See Plate LI.)—Body entirely brown, testaceous; back with three trigonate tubercles. (*Zool. Miscell.* i. 34.) From South Carolina.

Family III.—Holetra.

The groups composing this family are characterized by the union of the thorax and abdomen in a single mass, beneath a common epidermis. The thorax is almost divided into two by a contraction; and the abdomen, in some species, presents the appearance of rings, formed by the folds of the epidermis. The anterior extremity of the body frequently projects in the form of a beak or muzzle. The generality are provided with eight feet; some have only six.

Tribe I.—Phalangita, Latr.

Mandibles very conspicuous, terminated by didactylous pincers. Palpi filiform, and composed of five articles, of which the last is terminated by a small nail. Two distinct eyes. Two maxillæ formed by a prolongation of the radical article of the palpi; and besides these there are sometimes four other jaws, which, however, result merely from a dilatation of the haunches of the first two pair of legs. Body oval or rounded, and covered, at least on the thorax, by a skin of a somewhat solid texture. The legs, which are always eight in number, are long, and distinctly divided, like those of insects. Many are provided near the origin of the two posterior legs with two stigmata, one on either side, concealed by the haunches. The species of this tribe are for the most part of active habits. The generative organs are placed internally beneath the mouth.

Genus Phalangium, Linn. Fab.—Mandibles projecting, much shorter than the head. Eyes placed upon a common tubercle. The feet are long and slender, and when separated from the body they for some time afterwards exhibit signs of irritability. The females are provided with a membranous oviduct, filiform, annulated, and flexible. The tracheæ are tubular.

The species of this genus are of predacious habits. They prey upon small insects, which they seize with their mandibles, pierce with their crotchets, and suck to death. They are of pugnacious tempers. Though analogous to spiders in their external forms, they cannot spin. They are short-lived, as those hatched in the spring are all supposed to die in the autumn.

Sp. Cornutum, Linn. (the male). *Opilio, ejusd.* (the female).—Body oval, reddish or ash-coloured above, white beneath. Palpi long. Two rows of small spines on the tubercle which bears the eyes. Thighs with prickles. Mandibles horny in the males. A blackish band with a festooned border on the back of the female.

Of certain species of this genus Mr Kirby has formed his genus *Gonoleptes*. (See *Linn. Trans.* vol. xii. Plate XXII. fig. 16.)

Genus Siro, Latr.—Mandibles projecting, almost as long as the body. Eyes distant, each placed upon an isolated tubercle.

Sp. Rubens. (See Plate LI.)—Colour pale red; legs paler. Dwells in moss at the roots of trees.

Genus Macrocheles, Latr.—Mandibles long and projecting. Eyes sessile, or none. Two anterior feet, very long, and antenniform. The upper part of the body forms a plaque or scale, without any distinct rings.

According to Latreille, the *Acarus marginatus* and *testudinarius* of Hermann (*fils*) belong to this genus.

Genus Trogulus, Latr.—Anterior extremity of the body advanced in the form of a hood or *chaperon*, and receiving in an inferior cavity the mandibles and other parts of the mouth. The body is very flat, and covered by a strong skin.

Sp. Nepæformis.—Colour obscure ash-colour. Central portion of the dorsal part of the abdomen, and the sides, obsolctely subcarinated. External apex of the first joint of the tarsi produced. Inhabits France and Germany, lurking beneath stones.

Tribe II.—Acarides.

Sometimes furnished with mandibles composed of a single pincer, didactylous or with a simple claw, and concealed in a sternal lip; sometimes furnished with a sucker formed of plates or laminæ joined together. A few have only a simple cavity for the mouth, without additional appendages.

The species of this tribe (corresponding to the genus *Acarus* of Linnæus) are almost microscopical, and are universally distributed. Some are erratic, and occur in a great variety of situations, among stones, on trees, among flour, cheese, and various other substances, whether animal or vegetable; others are parasitical on the skins of living creatures, which they sometimes greatly weaken by their excessive multiplication. The disease called itch, if not occasioned by, is at least in some way connected with, the presence of minute species of this family. Dr Galet has demonstrated that that disease may be communicated by the transmission of mites from one (infected) individual to another. Small mites have even been found in the brain and in the eyes of the human race.

Many of the species, when first produced, have only six feet. They are oviparous, and deposit a great number of eggs.

Genus Trombidium, Fab.—Mandibles *en griffe*, or terminated by a movable claw. Palpi projecting, pointed, with a movable appendage or finger at the extremity. Two eyes, each placed at the end of a small fixed pedicle. Body divided into two parts, of which the first or anterior is very small, and bears, besides the eyes and mouth, the first two pair of legs.

Sp. Holosericeum.—Of a blood-red colour. Abdomen almost square, narrower behind, and notched. Back furnished with papillæ, hairy at the base, and globular at their extremities. Common in gardens during spring.

Sp. Tinctorum. (See Plate LI.)—This species is three or four times larger than the preceding. It occurs in the East Indies, and produces a fine dye.

Genus Erythræus, Latr.—Mandibles and palpi as in Trombidium, but the body is undivided, and the eyes are not mounted on a pedicle.

Sp. Phalangioides.—Legs very long, the last joint broad, compressed. Body obscure red, with a dorsal band of orange yellow. Inhabits most European countries, running on the ground with great rapidity.

Genus Gamasus, Latr.—Mandibles didactylous; palpi projecting, distinct, filiform.

Some species of this genus have the upper surface of the body clothed, in whole or in part, with a scaly skin, while others are entirely soft.

Sp. Coleoptratorum.—Anterior pair of legs somewhat longer than the others. Coriaceous parts of the back fuscous.

Inhabits the excrements of horses and cattle, and is frequently found adhering in great numbers to the bodies of coleopterous insects of the genus Scarabæus, Hister, &c.

To this genus belongs the *Acarus marginatus* of Hermann, which is sometimes found in the brain (*corpus callosum*) of the human race.

Genus Cheyletus, Latr.—Mandibles didactylous. Palpi thick, arm-shaped, falcated at the extremities.

Sp. Eruditus. Acarus eruditus, Schrank.—Colour brownish. Inhabits books and museums.

Genus Oribata.—Mandibles didactylous. Palpi short and concealed. Body covered by a coriaceous or scaly skin, in the form of a shield or buckler. Legs long, or of medium length.

The body in this genus is prolonged anteriorly in the form of a muzzle. There is sometimes an indication of a thorax. The ends of the tarsi are terminated by a single crotchet in some, by two or three in others, without any vesicular ball or cushion. The species are found beneath stones, among moss, and on trees. Their movements are slow.

Sp. Geniculata.—Of a brownish chesnut colour, shining, hairy. Legs pale brown, thighs sub-clavate. Common in Sweden, Germany, and England.

Genus Uropoda, Latr.—Mandibles pincer-shaped; palpi not conspicuous. Body covered by a scaly skin, and terminated by a slender filament, by means of which the species adhere to the bodies of coleopterous insects.

Sp. Vegetans. (See Plate LI.)—Brown, smooth, and shining. Inhabits France and England, attaching itself to the legs and other parts of insects by its pedunculated anus.

Genus Acarus, Fab. Latr.—Furnished like the preceding genera with didactylous mandibles, and very short or concealed palpi; but the body is soft, and unfurnished with a scaly crust. The tarsi are provided at their extremity with a vesicular tuft. Many species live on the substances used as aliments by the human race.

Sp. Siro. The cheese-mite. (See Plate LI.)—Whitish, with two brown spots. Body ovate, the middle coarctate, with long hairs. Legs of equal length. Inhabits houses, feeding on flour and long-kept cheese.

Sp. Scabiei. (See Plate LI.)—A microscopical species, which inhabits the skin of man in a diseased state. It appears, from the observations of Bonnani and others, that this insect usually accompanies the disease called the *itch*.

Genus Bdella, Latr.—Palpi elongated, bent, terminated by hairs or bristles. Four eyes, posterior feet the longest. Sucker prolonged in the form of a conical or awl-shaped beak. Found in moss, beneath stones, and under the bark of trees.

Sp. Rubra. La Bdelle rouge of Latreille. (See Plate LI.)—Rostrum longer than the thorax. Colour coccineous, legs paler than the body. Dwells beneath stones. This is the *pince rouge* of Geoffroy, and the *Acarus longicornis* of Linnæus. It is a minute insect, measuring scarcely half a line in length.

Genus Smaridia, Latr.—Distinguished from the preceding genus by the palpi, which are scarcely longer than the sucker; straight, and without bristles at the extremity. Eyes two. Anterior pair of legs longer than the others.

Sp. Sambuci. Acarus Sambuci, Schrank.—Colour red, the body slightly haired. Movements slow. Dwells beneath the bark of trees, more especially that of the elder, observed by Latreille in the south of France. This genus is represented in Plate LI. by a figure of *Smaridia passerina.*

Genus Ixodes.—Palpi inclosed in the sucker, along with which they form a short projecting beak, truncated, with a slight expansion at the end.

The animals of this genus occur among bushes and underwood, from which they detach themselves to fasten on dogs, sheep, cattle, and other quadrupeds, to which they adhere with remarkable tenacity. Their eggs, of which they lay a prodigious quantity, are, according to M. Chabrier, obtruded by the mouth.

Sp. Reduvius. Acarus reduvius, Linn. (See Plate LI.)—The colour and appearance of this species vary according to its state of repletion. The legs are black.

Genus Argas.—Palpi conical, composed of four articles, not inclosed in the sucker.

Sp. Reflexus. Acarus marginatus, Fab. (See Plate LI.)—Pale yellowish, or flesh-coloured, with deeper anastomosing lines. Inhabits houses in France, sucking the blood of doves.

A species of this genus found in Persia (the *malleh de mianeh*) is considered to be extremely poisonous. It appears, however, from the observations of M. Szovits, a naturalist recently employed by the Russian government to explore the Caucasus, that the bite of these bugs of Miana, as they are sometimes called (*Argas Persicus* of Fischer), is in reality by no means dangerous.

The three following genera correspond to the genus *Hydrachna* of Müller. Their habits are aquatic, and their forms oval, or nearly globular, and of a soft consistence. The number of their eyes varies from two to four, and even to six, according to Müller. They were usually confounded with the mites till the time of the last-named observer, who inferred that as they lived habitually in a different element, they ought to form a separate division. They resemble small spiders, and probably on that account received the name of Hydrachna, which signifies water-spider. Fabricius, who only employed in the formation of his groups characters drawn from the structure of the mouth, has united Hydrachna with Trombidium. The observations of Latreille have led not only to the distinct separation of these two genera, but to the subdivision of the genus Hydrachna into at least three distinct groups of species, all of which may be readily distinguished from the various kinds of mites (Acari) by their ciliated or natatorial legs.

The minute beings now under consideration occur

abundantly in stagnant or slowly moving waters. The spring season is the most favourable for the observance of their habits. They *run* through the water with great rapidity, with a continual movement of their legs. Their dispositions are carnivorous, and their food consists of animalcular species, of minute insects, small flies, and aquatic larvæ. Müller kept many Hydrachnæ in vessels of water full of *animalcula infusoria*, millions of which were eaten in a few days, soon after which the Hydrachnæ were found in a state of great languor, and transparent from exhaustion. They speedily revived when a few drops of water containing animalcules were mingled with that through which they swam.

The males are usually much less than the females, and the sexes frequently differ in colour. Only four or five species were known before the time of Müller, to whose persevering labours we owe the best elucidation which has yet been given of their history.[1]

Latreille is of opinion that the structure of the masticating organs authorizes the establishment of the three generic groups which follow.

Genus Eylais, Latr.—Mandibles terminated by a movable crotchet.

Sp. Extendens. Atax extendens, Fab. (See Plate LI.)—Body rounded, smooth, shining, immaculate, red. Hinder legs straight. Inhabits stagnant waters.

Genus Hydrachna, Latr.—Mouth composed of plates forming a projecting sucker. Palpi provided at their extremity with a movable appendage.

Sp. Geographica. (See Plate LI.)—Black, marked with coccineous spots. Inhabits gently flowing waters. A beautiful species, not uncommon in several parts of Britain.

Sp. Cruenta. (See Plate LI.)—Distended, red; legs of nearly equal length. This is the *Trombidium globator* of Fabricius, and the *mite aquatique ronde* of De Geer.

Genus Limnochares, Latr.—Resembles Hydrachna in its sucker-shaped mouth, but the palpi are simple.

Sp. Holosericea.—Body ovate, red, rugose, soft; eyes black. This is the *Acarus aquaticus* of Linnæus, and the *mite satinée aquatique* of De Geer. Inhabits the waters of Europe, and occurs frequently in ponds during the summer months. It varies in colour from a bright red to a grayish red. According to Fabricius, it deposits its eggs on water scorpions (*Nepæ*).

The remaining genera are distinguished from all other Arachnides by having only six legs. Their habits are parasitical.

Genus Caris, Latr.—Sucker and palpi apparent. Body rounded, very flat, and covered by a scaly skin.

Sp. Vespertilionis.—Body fuscous. Found on bats.

Genus Leptus.—Sucker and palpi apparent. Body soft and ovoid.

Sp. Autumnalis. Acarus Autumnalis, Shaw. (See Plate LI.)—Colour red, very minute. Common during the summer months on grasses and other plants, from which it detaches itself, and fixing in the skin of the human species, occasions an insupportable itching. "Acarus Autumnalis," says Dr Shaw, "popularly known by the name of the harvest bug, is also one of the most minute of the genus, and is of a bright red colour, with the abdomen bent on its hind part, with numerous white bristles. This troublesome insect will make itself sufficiently known to most people, during the months of July, August, and September. It is easily distinguishable on the skin by its bright red colour, and adheres so tenaciously when it has once fixed itself, as to be scarcely separated without violence; its motion when disengaged is pretty quick, though by no means equal to that of some other acari. On the part where it fixes it causes a tumour, generally about the size of a pea, sometimes much larger, accompanied by a severe itching. These insects abound on vegetables, and are generally contracted by walking in gardens, amongst long grass, or in corn fields." (*General Zoology*, vol. vi. p. 464.)

According to Mr White of Selbourne, this minute creature greatly abounds in the chalky districts of Hampshire. He was assured that the warreners are much infested by them, and are sometimes thrown into fever by their bites. Another species is common on *Phalangium opilio.*

Genus Aclysia, Audouin.—Form like that of a bagpipe. A syphon, without distinct palpi, placed beneath the anterior extremity, which is narrow, curved, and obtuse. The legs are very small.

The species of this genus are parasitical on the bodies of water-beetles of the genus *Dytiscus.* The only one of which we have any knowledge (*A. dytisci*) is described by M. Victor Audouin, in the 1st vol. of the *Mém. de la Soc. d'Hist. Nat. de Paris.* We found it on *Dytiscus marginalis*, in the vicinity of Edinburgh. A second species has been recently discovered in Russia by Count Manheiren.

Genus Astoma, Latr.—Neither sucker nor palpi visible. The mouth consists merely of a small opening, situated in the breast. The body is soft, and oval; the legs very short.

Sp. Parasitica. (See Plate LI.)—Body coccineous, slightly contracted in the centre. This is the *mite parasite* of De Geer. It inhabits the bodies of flies and other insects.

Genus Ocypete, Leach.—This genus, arranged by Dr Leach in the same stirps as *Trombidium*, is placed by Latreille at the end of his Hexapod Arachnides. It differs from those with which it is conjoined by the possession of mandibles.

Sp. Rubra, Leach, *Linn. Trans.* xi.—Colour red, back furnished with a few long hairs. The legs are covered with many hairs of a rufous cinerescent colour. The eyes are blackish brown. This curious little animal, which is not larger than a grain of sand, is parasitical, and frequently occurs on the larger tipulæ, adhering to their legs. Dr Leach obtained no less than 16 specimens from one insect. (T.)

[1] See O. F. Müller's *Hydrachnæ*, 1 vol. 4to, 1781.

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ARACHNOIDES, in *Anatomy*, an appellation given to several membranes,—as the tunic of the crystalline humour of the eye, the external lamina of the pia mater, and one of the coverings of the spinal marrow.

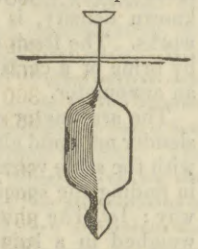
ARACK. See Arrack.

History. ARÆOMETER (composed of αραιος, *levis, tenuis*, and μετρον, *measure*), a measure of the comparative density and rarity of bodies. The name does not occur in ancient authors; hydroscopium and baryllium being the ancient names of the instrument. This instrument was known in the civilized part of the Roman empire about the year 400, as appears from the fifteenth epistle of Synesius, addressed to Hypatia, daughter of Theon; and to Hypatia some modern writers have erroneously ascribed its invention. The instrument is also described in some verses annexed to Priscian; and the principles on which its operation is founded are to be seen in the treatise of Archimedes on floating bodies (*De Humido Insidentibus*). The term, as used by writers on natural philosophy, is chiefly applied to instruments which are made to float, so as to indicate the specific gravity of the liquids in which they are placed: the *pêse liqueur* and hydrometer, in common use for measuring the specific gravity of vinous spirits, are instruments of this kind.

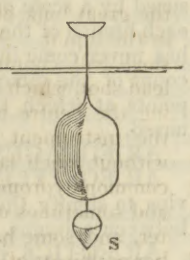
Theory. A floating body displaces a portion of the liquid, the weight of which is equal to its own weight: the liquid acting upwards with a force equal to this weight, and the weight of the body acting downwards with the same force, equilibrium takes place. If the body be afterwards placed in a liquid of less density, the part of the body immersed will be greater than when the body was in the more dense liquid, because it requires a greater volume of this less dense liquid to equal the weight of the floating body. The absolute weights of two bodies being the same, their specific gravities are in the inverse ratio of their volumes $\frac{G}{g} = \frac{v}{V}$, when G is put for the specific gravity of the first body, g for that of the second; V for the volume of the first, and v for the volume of the second. On this principle the common hydrometer is constructed; the instrument described by Synesius is also of this kind. In order that a small difference in the volume immersed may be sensible, the part which is intersected by the surface of the fluid is in the form of a very slender cylinder, the great bulk of the instrument being always immersed in the liquid. At the inferior part is a small ball, containing mercury or small lead shot, which serves as ballast, bringing the centre of gravity low, so that the instrument may float erect, and without much lateral oscillation. The common hydrometers are made of glass, and sometimes of brass, or tin or pewter, and some have been made of amber as objects of curiosity. When made of glass, a scale, inscribed upon paper, is inserted in the cylindrical stalk: the division of the scale at which the surface of any liquid intersects the stalk, denotes the specific gravity of that liquid. The divisions of the scale should be formed by immersing the instrument in liquids of known specific gravity, and marking a number corresponding to that specific gravity opposite to each division. The specific gravities of water and alcohol mixed in various proportions have been accurately ascertained by Mr

Gilpin. (See his Tables, and Dr Blagden's paper in the *Philosophical Transactions.*) On immersing the instrument in a mixture of known proportions of these two liquids, the point at which the surface intersects the stalk is to be marked with the number expressing the specific gravity of the mixture taken from the table. Some hydrometers, such as that constructed by the French chemist Beaumé, and which is much used in France under the name of *Aréomètre de Beaumé*, have the scale divided into equal parts, so that the divisions do not correspond as they ought to do with the numbers which express specific gravities.

In the aræometer of Fahrenheit, the uncertainty arising from the erroneous division of the scale is obviated, no division being required. The form of the instrument is the same as that just described, only at the top there is a small cup, into which weights are put, so as to bring the surface of the denser liquid to a fixed mark on the stalk: when the instrument is placed in a liquid of less density, some of the weights are taken out till the mark again comes to the surface. Suppose the weight of the instrument and of the weights in the cup together equal to 1000, when sunk to the mark in distilled water at a certain temperature; the instrument is now taken out of the water and immersed in a liquid, where 10 must be taken out of the cup in order to bring the mark to the surface; the immersion in water indicates that a volume of water weighs 1000; the immersion in the second liquid shows that an equal volume of this liquid weighs 990; when the volumes of bodies are equal, the specific gravities are directly as the absolute weights $\frac{G}{g} = \frac{W}{w}$, consequently the specific gravity of the second liquid is 990, that of water being 1000. To save computation, it is convenient that the whole weight of the apparatus, when in distilled water at a certain temperature, should be represented by 1000; for this purpose the instrument-maker divides the weight of the apparatus into 1000 parts, and forms small weights consisting of one, two, three, &c. of these 1000th parts, the relation of which to the ounce or pound does not require to be known; the weights thus formed are to be used with the instrument.



The aræometer of Nicholson is like that of Fahrenheit, with the addition of an immersed cup, whereby it is rendered proper for ascertaining the specific gravity of solids. Suppose that it requires 400 grains in the exterior cup to sink the instrument to the mark in distilled water, at 60 degrees of Fahrenheit's thermometer; 1*st*, The body under examination is put into the exterior cup, and weights (say 300 grains) are taken out till the mark again stands at the surface; this gives the absolute weight of the body 300 grains. 2*dly*, The body is then put into the immersed cup S, taking care to brush off any air-bubbles with a hair pencil, and in order to bring the mark to the surface, a weight (say 100 grains) must be put into the exterior cup, that is, the weight of a volume of water equal to the body is 100 grains. The first part of the process gave the absolute weight of the body 300 grains; and the volumes being equal, the specific gravities are as the absolute weights; consequently the specific gravity of the body is 300, that of water being 100. This aræometer may be used to find the specific gravity of liquids: the process, in that case, is the same as that described above in speaking of the aræometer of Fahrenheit. The aræometer of Nicholson is useful to the mineralogist for ascertaining the specific gravity of minerals, the specific gravity being a convenient character for distinguishing one kind of mineral from another. It is sometimes made of tinned iron, but where more accuracy is required, copper is the material employed. When put together, it does not exceed a foot in length, and therefore is suited to form a part of the travelling mineralogist's apparatus.



Aræometer.

Some aræometers have been constructed with the exterior cup C placed underneath, and supported by a stirrup, whose upper part is fixed to the stalk of the aræometer, as represented on the margin. This is done in order to place the centre of gravity low, that the aræometer may thereby float more steadily. The aræometer floats in a cylindrical vessel fitted to the size of the stirrup, and this vessel is supported on a stand so formed as not to interfere with the free motion of the stirrup.

Deparcieux's.

The aræometer of Deparcieux is like the common hydrometer, only the ball is much more voluminous. This renders it capable of indicating the small difference which exists in the specific gravity of the water of different springs, for which purpose Deparcieux proposed it. The dilatation of the large glass bulb by heat has a considerable effect on the operation of this instrument, and this dilatation being different in different instruments, renders the results inaccurate. The different aræometers above mentioned have the advantages of being easily made and easily carried about; but where the specific gravity of a body is required with the greatest accuracy, recourse must be had to the hydrostatic balance, which ought to be constructed with the utmost care by the most skilful artist.

The following algebraic expressions may serve to elucidate some of the properties of the aræometers hitherto spoken of:

g is the specific gravity of water, which is 1000 ounces when the ounce and foot are taken as unities, 1000 ounces avoirdupois being the weight of a cubic foot of water.

z is the diameter of the wire-stalk of the aræometer.

π is 3·1415, &c. the number expressing the periphery of a circle whose diameter is 1.

$\frac{1}{4}\pi z^2$ is the surface of a transverse section of the wire-stalk.

v is the volume of the bulb or body of the aræometer.

w is the whole weight of the aræometer.

x is the length of the stalk that is plunged in the water.

$\frac{1}{4}x\pi z^2$ is the volume of the immersed portion of the stalk.

When the aræometer floats in equilibrio, it displaces a volume of water equal to its own weight; therefore, $w = g\,(v + \frac{1}{4}x\pi v^2)$, and, $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, $x = \frac{4(w - gv)}{2g\pi z^2}$: $w - gv$ is the difference between the quantity of water displaced by the whole aræometer, and the quantity displaced by the bulb alone; $w - gv$, therefore, is the volume of water displaced by the immersed portion of the stalk. As the diameter of the stalk z is very small, the cylinder of water $w - gv$, which has z for its diameter, is likewise very small, and does not exceed a few grains in weight; therefore a small variation in w (the weight of the aræometer), or in g (the density of the liquid), occasions a great variation in x (the length of the immersed part of the stalk). The value of x changes rapidly, when z (the diameter of the stalk) is changed.

Aræometer.

because the value of x is divided by z^2, which is the square of a very small quantity.

Sensibility to the specific gravity of liquid.

When the aræometer is immersed in a liquid of another specific gravity g^1, then the equation is $x^1 = \frac{2(w - g^1 v)}{g^1 \pi z^2}$; subtract the value of x^1 from that of x, and there results $x - x^1 = \frac{2w(g - g^1)}{gg^1 \pi z^2}$. This is the diminution in the length of the immersed part of the stalk, which takes place when the aræometer is transferred to a liquid of a greater density. By this formula it is seen, that the sensibility of the aræometer, that is, the length of the portion of the stalk which emerges upon transferring the aræometer to a denser liquid, is augmented, in the first place by increasing w (the weight of water displaced by the aræometer), that is, by increasing the volume of the body of the aræometer; secondly, by diminishing z (the diameter of the stalk), which is in the denominator of the value of $x - x^1$; consequently, the faculty of the aræometer to show the different densities of liquids is in general expressed by the fraction $\frac{w}{z^2}$.

With regard to the vertical mobility of the aræometer, when put in motion by placing a small weight s in its exterior cup, substitute $w + s$ for w; then, $x^1 = \frac{4(w + s - gv)}{2g\pi z^2}$. Take the difference between this and $x = \frac{4(w - gv)}{2g\pi z^2}$: this difference is $x^1 - x = \frac{4s}{g\pi z^2}$; which shows that the length of the portion of the stalk that a small weight causes to immerge is proportional to $\frac{s}{z^2}$, or in the direct ratio of the small weight, and in the inverse ratio of the square of the diameter of the stalk.

When the small weight, the density of the liquid, and the length of that part of the stalk which is submerged on adding the small weight, are known, then this equation will give the diameter of the stalk in known quantities $z = 2\sqrt{\frac{s}{g\pi(x^1 - x)}}$.

When the weight of the whole aræometer is known in ounces, &c., and the specific gravity of one of two liquids (water, for instance) is known, the difference of specific gravity between that liquid and another liquid may be had in known quantities.

g is the specific gravity of water.

g^1 is the specific gravity of the second liquid, which is here supposed more dense.

w is the weight of the volume of water displaced by the aræometer.

s is a small additional weight placed on the exterior cup to keep the aræometer, when placed in the denser liquid, at the same point of immersion as when it floated in water.

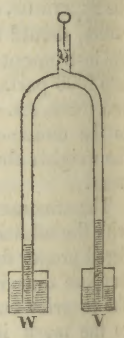
$w + s$ is the whole weight of the apparatus when floating in the denser liquid.

The equation $g^1 = \frac{w + s}{v + \frac{1}{4}x\pi z^2}$ is obtained by substituting g^1 for g, and $w + s$ for w, in the equation $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, which was given above. Divide by $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, and there results $\frac{g^1}{g} = \frac{w + s}{w}$, which gives the proportion of the density of the second liquid to the density of water. By subtraction there results $\frac{g^1 - g}{g} = \frac{s}{w}$ and $g^1 - g = \frac{sg}{w}$; that is, the difference between the density of the second liquid and the density of water is found by multiplying the small weight by 1000 ounces, and dividing this product by the number of ounces, &c. which denote the weight of the aræometer uncharged.

Small bodies, whose specific gravities are known, serve to indicate the specific gravity of a liquid in which they just remain suspended. In this way beads of glass three or four tenths of an inch in diameter are employed, each of which remains suspended in spirit of a certain specific gravity. The density of each of these beads, or rather bubbles, is regulated by the proportion between the quantity of glass and the cavity which the glass incloses. A piece of bees-wax, whose specific gravity, by the addition of lead, is such that the body is just suspended in brine of a known density, is used as an aræometer in some salt works. The fresh egg of a common fowl is just sustained by brine of a certain specific gravity, and is employed as an aræometer.

The aræometer of Homberg consists of a phial with a slender neck and glass stopper, so made that it may be filled with the same volume of different liquids. It is employed in finding the specific gravity of liquids in the following way: 1*st*, The phial is filled with distilled water, and then weighed in a balance; 2*dly*, the phial is emptied, and again filled with the liquid whose specific gravity is sought, and weighed in a balance: the proportion of the weight of the contents of the phial in the second process to the weight of its contents in the first, is the specific gravity required. The inconveniences which have prevented this method from being generally used are, the difficulty of completely cleaning the phial from the liquid which it previously contained; the difficulty of filling the phial exactly with the same volume of each liquid; and the variation of the volume of the phial from changes of temperature.

The pressure of the atmosphere supports columns of different fluids, whose height is inversely as the densities of the fluids. An aræometer has been constructed on this principle. It is a curved tube, one leg of which has its extremity immersed in water, and the other in the spirit whose density is to be tried. On rarefying the air in the tube, by means of a pump fixed at the upper part of the tube, the water ascends in one leg, and the spirit in the other; the height of the column of each liquid being measured by a scale of equal parts applied to each branch of the tube. This instrument has never come into use, probably on account of the difficulty of ascertaining with precision the points at which the surfaces of the columns are terminated. (BB.)



ARÆOPAGUS. See ATTICA.

ARÆOSTYLE, in *Architecture*, a term used by Vitruvius to signify the greatest interval which can be made between columns.

ARÆOTICS, in *Medicine*, remedies which rarefy the humours, and render them easy to be carried off by the pores of the skin.

ARAFAH, the ninth day of the last month of the Arabic year, named *Dhoulhegiat*, on which the pilgrims of Mecca perform their devotions on a neighbouring mountain called Arafat.

ARAFAT, MOUNT, a celebrated mountain in Arabia, held in high veneration by the Mahometans. A visit to this mountain constitutes a necessary part of the religious pilgrimage to Mecca; which we have described at

length under the article Arabia. The mountain consists of a granite rock about 150 feet high, which is ascended by staircases, partly cut in the rock and partly composed of solid masonry. On the summit is a chapel, which the Mahometans believe to have been built by Adam. On this hill also Adam is said to have met his wife Eve after a long absence; and it is thence called Arafat or *Gratitude*. The interior of the chapel was destroyed by the Wahabys in 1807.

ARAGON, or ARRAGON, a province, or, as it is usually denominated by the inhabitants of the peninsula, a kingdom, of Spain, and one of the component parts of that monarchy, situated between 40. 17. and 42. 51. N. lat. It is almost surrounded by Old and New Castile, but to the south the province of Valencia adjoins it and a small part of Catalonia. It is the most thinly peopled and the most extensive of all the European dominions of the Spanish crown. Its superficies is 1232 square leagues; and its population, according to the census of 1803, was 657,376 souls. It is indeed contended that the numeration of that period was incorrect; but the highest calculation, made by the Economical Society of Saragossa, makes it amount to but a few hundreds more than the census on which we rely. The province is nearly divided into two equal parts by the river Ebro, which are distinguished by the appellations of *trans-ibero* and *cis-ibero*. Its surface is very irregular: the north-east part towards Old Castile begins with the Sierra de Moncayo, but from the foot of these mountains to the Ebro the country is a continued level and fertile plain in the centre. To the south the ground rises gradually till it attains considerable elevation in the mountains near Cuença, in which are the sources of the most considerable rivers of Spain, some of which direct their courses to the Mediterranean, while others force their way to the Atlantic.

The agricultural productions of the province necessarily vary with the variations in the elevation and aspect of the land. The greater part is appropriated to feeding flocks of Merino sheep. The number of those belonging to the inhabitants of Aragon amounted to 2,050,000, and their wool forms the most important of the productions of the province. Wheat is grown more than sufficient for its own consumption, and it contributes to feed the neighbouring province of Navarre. Its wine and oil are generally more than its own demands require, and they are both of the best quality which Spain produces; but having none but difficult communication with any other country where these valuable articles are wanted, the cultivation of them languishes. Near the banks of the Ebro flax and hemp are grown in more than sufficient quantities for the domestic manufactures; and a supply of the latter is furnished to some of the maritime towns of Biscay, where it is preferred for cables to any other. The whole annual quantity of its growth is 1000 tons. The supply of horses and cows is not equal to the demands of the inhabitants, and the deficiency is made up from the breed of the adjoining provinces. The mountainous parts abound with excellent ship-timber, but the badness of the roads prevents this branch of commerce from being carried to any great extent.

The manufactures of the province are inconsiderable; that of silk, which was formerly extensive, has been gradually on the decline for some years. Manufactories for coarse cloths occupy the inhabitants of the town, or, as they call it, the city, of Albarracin, and the large village of Tarazona; and some cloths of fine wool are made at Jaca, and some baize in its vicinity. Some linen and sail-cloth are also made, but the quantity of each is small. There are iron manufactories on the mountains, where the abundance of trees calculated for making charcoal have introduced forges; but the badness of the roads checks their extension.

Aragon is not deficient in mineral riches, though the labour applied to them, as to most other objects in Spain, is in a very languid state. Near the Pyrenees, besides mines of iron, there are three mines of lead and one of copper, and, what is unique in Spain, a mine of cobalt. Besides these there is a mine of alum near Alcaniz, which is very productive.

Though the soil is generally very dry, and the greater part of the province suffers from the want of water, yet the largest rivers of Spain, the Tagus, the Guadiana, and the Xucar, have their sources within it, and by their early streams water the valleys, whilst, as before noticed, the Ebro runs through its centre. At two leagues N. N. E. of Albarracin is the extraordinary fountain called Cella, at an elevation of 3700 feet above the level of the sea. From this fountain the river Xiloca issues, and running through a beautiful country of 30 miles in extent, filled with inclosures, orchards, gardens, and vineyards, joins its waters, near Calatayud, to the more copious stream of the Xalon, which descends from Old Castile; and these united, lose their names by being emptied into the Ebro. Between the stream of the Xiloca and the mountains which separate Aragon from Molina, is a very extensive lake called Gallo-canta, which covers about 6000 acres of land; and at a little distance from the lake are the ruins of the ancient city Bilbilis, which has derived celebrity from being the native place of the Roman poet Martial. The Ebro receives the tributary streams of the Gallego and the Guerva just as it reaches the walls of Saragossa; and soon after the Martin joins it near the populous town of Caspe. In this vicinity are abundant coal-mines, which supply the inhabitants and the manufactories with that valuable fuel. In Aragon trans-ibero the river Cinca, issuing from the Pyrenees, passes the town of Ainsa, the former residence of the ancient kings of Aragon; and, increased by the streams of the Esera, the Vero, and the Alcanadre, in its passage to the Ebro, fertilizes the lands near the city of Huesca. In this place is a university and two colleges, the former of which is a building of great antiquity and considerable magnificence; and it is surrounded by the ruins of very ancient fortifications. After receiving, besides the streams noticed, several copious rivulets, whose short courses have scarcely received any names, the Ebro enters the province of Catalonia, and at length falls into the Mediterranean Sea near Tolosa.

The capital of Aragon is Saragossa, or, as the Spaniards spell it, Zaragosa, a city of more than 50,000 inhabitants; the description of which, with its memorable resistance to the French invaders, will be treated of under the article SARAGOSSA. The other considerable cities and towns are Teruel, Daroca, Calatayud, Borja, Tarazona, Alcaniz, Caspe, Barbastro, Monzon, Huesca, and Jaca. At the most southern part of the province a district called Cinco-villas is remarkably fruitful. The whole extent of 17,000 acres derives its fertility principally from an artificial canal, cut for the purpose of irrigation, called the royal canal of Tauste, by means of which the whole of the land may be flooded at pleasure.

The name of this kingdom was derived from the small but precipitous torrent Aragon, which rises in the Pyrenean Mountains, and, running from north to south, forms part of the waters of the Ebro.

A great portion of the Pyrenees is in the province of Aragon. They run from east to west, presenting towards Spain the convex part of a kind of spherical segment, losing their height gradually towards each extremity. The highest point of this range of mountains, called by the French Mont Perdu, and by the Spaniards Las Tres Sorores, is visible from the city of Saragossa. According to the actual measurement of the naturalist Ramond, who

reached its summit in 1802, it is 11,430 feet above the level of the sea. Its top is constantly covered with snow, the permanent limits of which, on the same authority, are stated at 7750 feet of elevation. Before the measurement of Ramond, the point called Canigu was supposed to be the highest peak of this range, but it was thereby ascertained to be but 10,050 feet high.

The regular passages from Spain into France are none of them through any of the ridges within the province of Aragon. One of them is in Biscay, one in Navarre, and one in Catalonia; but on an accurate survey by the French engineers, it appeared there were upwards of eighty practicable passages, of which twenty-eight would allow of cavalry, and seven of artillery and wheel-carriages. None of these had been ever examined by the Spanish government, though it was more than suspected that a very considerable contraband traffic had been conducted through these passes, in spite of the vigilance of the officers of revenue in both kingdoms.

The history of Aragon before its union with Castile by the marriage of Ferdinand and Isabella, when it was merged in the kingdom of Spain, will be found in the general history of that country. *Viage de* Ponz; *Geografia de* Don Isidoro de Antillon; *Historia de la Economia Politica de Aragon*, por Don Ignacio de Asso. (G.)

ARAHUM, or Harahum, in ancient writers, denotes a place consecrated or set apart for holy purposes. Hence the phrase *in araho jurare*, or *conjurare*, to make oath in the church; because, by the Ripuarian laws, all oaths were to be taken in the church on the relics of the saints.

ARAL, a great lake lying a little to the eastward of the Caspian Sea. Its length from north to south is said to be near 150 miles, and its breadth from east to west about 70. The shore on the west side is high and rocky, and destitute of good water; yet there are abundance of wild horses, asses, antelopes, and wolves; as also a fierce creature called a *jolbart*, which the Tartars say is of such a prodigious strength as to carry off a horse. Several great rivers, which were supposed to run into the Caspian Sea, are now known to fall into this lake, particularly the Sihun or Sirr, and the Ghihun or Amo, so often mentioned by the oriental historians. This lake, like the Caspian Sea, has no visible outlet. Its water is also very salt, and for that reason is conveyed by the neighbouring inhabitants by small narrow canals into sandy pits, where the heat of the sun, by exhaling the water, leaves them a sufficient quantity of salt.

ARAMONT, a town of Languedoc in France, seated on the river Rhone. Long. 4. 52. E. Lat. 43. 54. N.

ARANDA de Duero, a town of Spain, in Old Castile, in the province of Burgos, on the right bank of the river Duero. It contains 3300 inhabitants. Long. 3. 9. 24. W. Lat. 41. 40. 12. N.

ARANJUEZ, a town of Spain, about 20 miles from Madrid. It is situated on the banks of the Tagus, a little below the junction of the rivers Xarama, Manzanares, and Tajuna with that stream. The town is small, but well built, and the principal street, the *Calle Reyna*, is one of the most beautiful in Spain. Near this town is one of the royal residences. The palace has been built and ornamented with most profuse expense by several successive monarchs. The expenditure on this place is estimated to have amounted to more than L.500,000 sterling between the years 1763 and 1776. The gardens were much improved by Wall, the extravagant minister of the grandfather of the present king. Having the advantage of the Tagus and several tributary rivulets, their waters have been employed in forming fountains and cascades among the various beautiful retreats which the woods afford. The buildings are both spacious and magnificent; and the apartments are, or rather, before the French plunderers visited it, were, adorned with some exquisite paintings from the pencil of Titian and of Mengs. When this place was first appropriated as a royal residence, Charles III. was principally induced to occupy it for the sake of the game which abounds, to the pursuit of which he was excessively addicted. The injury done to the occupiers of the land in the vicinity of Aranjuez by the parties of the royal establishment was such, that the compensations which the king made to them for the damages sustained amounted in some years to the enormous sum of L.70,000 sterling. The town contains, when the court is at Aranjuez, about 10,000 inhabitants. Lat. 40. 1. 54. N.

ARARAT, a lofty mountain of Armenia, which rises from the adjacent plain to the height of 9500 feet. It has two peaks covered with perpetual snow, which, viewed from the north, are seen to be separated by a deep glen in the body of the mountain. From the slope of this deep cleft the lesser head rises in a perfectly conical shape. The larger peak is of the same form, only more rounded at the top; and the north-west face of the mountain is broken and abrupt, and opens half-way down into a stupendous rocky chasm of great depth, and peculiarly black. Many travellers have attempted to scale the summit of this tremendous mountain. But the distance between the commencement of the perpetual snow line and the summit, and the long-continued cold to which the traveller would consequently be exposed, baffled for a long time all such hazardous attempts. Lately, however, a German traveller, accompanied by a companion, accomplished this daring feat, and attained the snowy summit, on which no human foot had ever trod before. The mountain is held in peculiar veneration by the Armenian Christians, from the belief that Noah's ark after the flood rested on its summits. It is evidently of volcanic origin; but Dr Reinegg's assertion, that an eruption occurred in 1783, is totally devoid of foundation. This fact was ascertained by Sir R. K. Porter from the priests of a neighbouring monastery, where an account was kept of the appearances exhibited by the monastery for several centuries back.

ARASSI, a maritime, populous, and trading town of Italy, in the territory of Genoa. Long. 7. 20. E. Lat. 44. 3. N.

ARATEIA, in *Antiquity*, a yearly festival celebrated at Sicyon, on the birth-day of Aratus, wherein divers honours were paid by a priest consecrated to this service, who for distinction's sake wore a riband bespangled with white and purple spots.

ARATUS, general of the Achæans, conquered Nicocles, tyrant of Sicyon. Two years after he surprised Acrocorinthus, and drove out the king of Macedonia: he delivered Argos from its tyrants, and was poisoned by Philip II. king of Macedonia, whom he had newly restored. He was about 62 when he died, the second year of the 141st Olympiad. He was interred at Sicyon, and received the greatest honours from his countrymen.

Aratus, a Greek poet, born at Soli, or Solæ, a town in Cilicia, which afterwards changed its name, and was called Pompeiopolis in honour of Pompey the Great. He flourished about the 124th, or, according to some, the 126th Olympiad, in the reign of Ptolemy Philadelphus, king of Egypt. He discovered in his youth a remarkable poignancy of wit, and capacity for improvement; and having received his education under Dionysius Heracleotes, a Stoic philosopher, he espoused the principles of that sect. Aratus was physician to Antigonus Gonatus, the son of Demetrius Poliorcetes, king of Macedon. His

poem entitled *Phænomena* describes the nature and motion of the fixed stars, and shows the particular influences of the heavenly bodies, with their various dispositions and relations. He wrote this poem in Greek verse. It was translated into Latin by Cicero, who tells us, in his first book *De Oratore*, that the verses of Aratus are very noble. This piece was translated by others as well as Cicero, there being a translation by Germanicus Cæsar, and another into elegant verse by Festus Avienus. An edition of the *Phænomena* was published by Grotius, at Leyden, in quarto, in 1600, in Greek and Latin, with the fragments of Cicero's version, and the translations of Germanicus and Avienus; all which the editor has illustrated with curious notes. A valuable edition of the *Phænomena* was published at Oxford, by Fell, in 1672, in 8vo; but the most complete is that of Buhle, published at Leipsic in 1801, in 2 vols. 8vo. There are several other works ascribed to Aratus. Suidas mentions the following:—Hymns to Pan; Astrology and Astrothesy; a composition of Antidotes; an Επιθυτικον on Theopropus; an Ηθοποια on Antigonus; an Epigram on Phila, the daughter of Antipater and wife of Antigonus; an Epicedium of Cleombrotus; a Correction of the Odyssey; and some Epistles in prose. Virgil, in his Georgics, has imitated or translated many passages from this author; and St Paul has quoted a passage of Aratus. It is in his speech to the Athenians (Acts xvii. 28), wherein he tells them that some of their own poets have said, Του γαρ και γενος εσμεν, For we are also his offspring. These words are the beginning of the fifth line of the *Phænomena*.

ARAUCANIA, a district of Chili, in South America, lying between 37° and 39° of south latitude. The Araucanians had a certain tincture of civilization, which was united with a high and unconquerable spirit of independence. They warred with the Spaniards for more than a century, and though often vanquished in the field, never would submit to them. Their government, according to Molina, was a sort of federal republic; and they had a nobility, and held national councils annually. The number of fighting men in the four districts which composed Araucania was about 7000 or 8000. They still enjoy their independence. See AMERICA.

ARAUSIO, *Civitas Arausiensis* or *Arausicorum*, or *Colonia Secundanorum*; so called, because the veterans of the second legion were there settled; now *Orange*, in the west of Provence, on an arm of the rivulet Egue. An ancient amphitheatre is still to be seen here. Long. 4. 46. E. Lat. 44. 10. N.

ARAW, a town of Switzerland, in Argow, seated on the river Aar. It is handsome, large, and remarkable for its church, its fountain, and the fertility of the soil. Long. 8. 0. E. Lat. 47. 25. N.

ARBACES governed Media under Sardanapalus. Seeing him spinning among a company of his women, he stirred up his people to revolt, and dethroned Sardanapalus, who thereupon burnt himself in his palace. Arbaces being crowned, began the monarchy of the Medes, which lasted 317 years under nine kings, till Astyages was expelled by Cyrus. Arbaces reigned 22 years, and died A. M. 3206.

ARBALEST, or CROSS-BOW. See CROSS-BOW.

ARBE, anciently ARBA, an island and city of Illyria, in the gulf of Quarnaro. Of this island, which has been but slightly noticed by geographers, there is a full account in the Abbé Fortis's *Account of Dalmatia*. The appearance of the island is exceedingly pleasant. On the east it has a very high mountain, at the foot of which the rest of the island is extended to the westward, and divided into beautiful and fruitful plains interspersed with little hills fit to bear the richest products. At the extremity that looks to the north a delightful promontory, called Loparo, stretches into the sea: it is crowned with little hills, which almost quite inclose a fine cultivated plain. Near this promontory are the two small islands of S. Gregorio and Goli. The city of Arbe stands on a rising ground between two harbours, which form a peninsula.

ARBELA, now IRBIL, a city of Assyria, lying in long. 44. 5. E. lat. 35. 15. N. It is famous for the last and decisive battle fought in its neighbourhood between Alexander the Great and Darius Codomannus. This battle was fought 331 years before Christ, and determined the fate of the Persian empire. Arrian relates, that Darius's army consisted of a million of foot and 40,000 horse; according to Diodorus, there were 200,000 horse and 800,000 foot; Plutarch relates that the horse and foot together made up a million; and Justin gives us exactly half Diodorus's number. The Macedonian army, according to Arrian, consisted of 40,000 foot and 7000 horse. "With the loss of 500 men," says Dr Gillies, "Alexander destroyed 40,000 of the barbarians, who never thenceforth assembled in sufficient numbers to dispute his dominion in the East. The invaluable provinces of Babylonia, Susiana, and Persis, with their respective capitals of Babylon, Susa, and Persepolis, formed the prize of his skill and valour. The gold and silver found in those cities amounted to thirty millions sterling; the jewels and other precious spoil belonging to Darius sufficed, according to Plutarch, to load 20,000 mules and 5000 camels." (Gillies's *History of Greece*.)

ARBERG, a town of Switzerland, in the canton of Bern, with a handsome castle, where the bailiff resides. It is seated on the river Aar, in a kind of island. Long. 7. 15. E. Lat. 47. 0. N.

ARBITER, in the *Civil Law*, implies a judge nominated by the magistrate, or chosen voluntarily by the two contending parties, in order to decide their differences. The civilians make a difference between *arbiter* and *arbitrator*, though both found their power on the compromise of the parties; the former being obliged to judge according to the customs of the law, whereas the latter is at liberty to use his own discretion, and accommodate the differences in the manner that appears to him most just and equitable.

ARBITRARY, that which is left to the choice or arbitration of men, or not fixed by any positive law or injunction.

ARBITRARY Punishment, in *Law*, denotes such punishments as are by statute left to the discretion of the judge. It is a general rule in arbitrary punishments, that the judge cannot inflict death. Hence all punishments that are not capital have acquired the name of *arbitrary punishments*, even although they be expressly pointed out by statute.

ARBOIS, a small populous town of France, in the department of Jura, formerly Franche Compté, famous for its wines. Long. 5. 40. E. Lat. 46. 55. N.

ARBON, one of the eight circles into which the canton of Thurgaw is divided.

ARBON, a town of Switzerland, chief of the circle of the same name. It contains 170 houses and 900 inhabitants, about equally catholics and reformed protestants, who use the only church alternately, and divide the magistracy between them equally. It has a considerable trade in linen goods. It is on the lake of Constance. Long. 9. 25. E. Lat. 42. 27. N.

ARBOUR, in *Gardening*, a kind of shady bower, formerly in great esteem. Arbours are generally made of lattice work, either of wood or iron; and covered with elms, limes, and hornbeams; or with creepers, as honeysuckles, jessamines, or passion-flowers; either of which will answer the purpose very well, if rightly managed.

Arbroath || Arbuthnot.

ARBROATH. See ABERBROTHICK.

ARBURG, a town of Switzerland, in the canton of Bern, on the river Aar. It is small, but very strong, being seated on a rock, and defended by a good fortress cut out of the rock. Long. 7. 55. E. Lat. 47. 10. N.

ARBUSTUM implies a number or multitude of trees planted for the fruit's sake. The word was more peculiarly applied to a place planted with trees for fastening vines to, which are hence called by Columella *Arbustivæ*.

ARBUSTUM is sometimes also used to denote an orchard, or field wherein trees are planted at such distance that there is room for ploughing and growing corn between.

ARBUTHNOT, ALEXANDER, principal of the university of Aberdeen in the reign of James VI. of Scotland, was born in the year 1538. He studied first at Aberdeen, and was afterwards sent over to France, where, under the famous Cujacius, he applied himself to the study of the civil law. In the year 1563 he returned to Scotland and took orders. Whether he was ordained by a bishop or by presbyters is a matter of uncertainty. In 1568 he was appointed minister of Arbuthnot and Logie Buchan; and in the following year Mr Alexander Anderson being deprived, our author was made principal of the King's College at Aberdeen in his room. In the general assembly which met at Edinburgh in the years 1573 and 1577 he was chosen moderator, and to the end of his life was an active supporter of the reformed religion. He died in 1583, in the 45th year of his age, and was buried in the College church of Aberdeen. It was by him that Buchanan's *History of Scotland*, published in 1582, was edited. The only production of his own is his *Orationes de Origine et Dignitate Juris*, printed at Edinburgh in 1572, 4to. His contemporary Thomas Maitland wrote a copy of Latin verses on the publication of this book: they are printed in the *Delit. Poet. Scot.* The same collection contains an elegant epitaph on him, written by Andrew Melvil.

ARBUTHNOT, *John*, M. D. the son of an episcopal clergyman in Scotland, was born soon after the Restoration, at Arbuthnot near Montrose. After acquiring a competent knowledge of the elementary parts of education, he was sent to the college of Aberdeen, where the buddings of those great qualities and those sallies of wit, which contributed so much to his future greatness, soon made their appearance. Having there gone through a course of academical studies, and obtained the degree of doctor of physic, he went to London in order to reap the fruits both of his natural and acquired abilities. He then began to display his talents in teaching mathematics, in which he was very expert. *An Examination of Dr Woodward's Account of the Deluge*, &c. in 1697, first made him known to the learned world. This performance was received with great applause; and in 1700 a treatise *On the Usefulness of Mathematical Learning* still increased his reputation. A very interesting paper *On the Regularity of the Births of both Sexes*, demonstrating from authentic proofs the universal similarity which is observed by nature in this circumstance, and drawing from these several political and moral inferences, which he presented to the Royal Society, procured his election in 1704 into that body. Meanwhile, in his own proper profession, he was acquiring considerable eminence, and was appointed, on account of his great medical knowledge, physician extraordinary to Prince George of Denmark, and shortly afterwards one of the physicians in ordinary to Queen Anne. He was admitted in 1710 a fellow of the college. He formed about this period a very intimate acquaintance, which lasted with unabating tenderness and affection during the rest of his life, with these great literary men, Pope, Gay, and Swift. In 1714 he engaged in an extensive design of making a satire upon all the abuses of science in every branch, in co-operation with Pope and Swift, which was to be written under the form of the history of a fictitious character, and in the grave ironical style. The plan was never finished, but the *Memoirs of Martinus Scriblerus*, published in Pope's works, form a part, of which much is the performance of Dr Arbuthnot. It is very probable that the whole of the first book is of his composition, in which the great profoundness of knowledge that is discerned, and the good-natured pleasantry with which the satire is directed, has gained it the character of one of the most original, learned, and interesting pieces in the English language. Those parts which relate to anatomy, the manners and customs of antiquity, and logic, are particularly his performance. On the death of Queen Anne he made a visit to Paris, in order to drive away the melancholy which attended him on account of that circumstance, which was a severe stroke to him, and destructive not only to his personal, but also to his political views. Returning from thence, as his medical services were no longer required at St James's, he retired from it, and followed at large the practice of his profession; yet he did not thence give up his literary pursuits, but pursued them with great ardour, although long intervals took place between the times of his publications. A work entitled *Tables of Ancient Coins, Weights, and Measures*, explained and exemplified in several dissertations, appeared in 1727, in a 4to volume, which is the chief of his serious performances. Although there are several inaccuracies in it which could hardly be avoided in so intricate a subject, it is a work of great merit, and has ever since been considered as the standard authority. A treatise *On the Nature and Choice of Aliments*, which was published in 1732, and another published in 1733, *On the Effects of Air on Human Bodies*, finish the list of his sterling works. Both these were well received by the faculty, and continue to be still esteemed, and are occasionally read and quoted. Respecting his humorous works, which were the productions of his leisure hours, they are so confounded with those of his contemporaries, that it is not easy to distinguish them. But a piece which, independent of any other, would raise him to the character of the first humorous writer in the English language, entitled the *History of John Bull*, is confidently ascribed to him. This is conducted with great wit and humour, and all the circumstances and characters are most admirably adapted. Among his several avowed ironical pieces are, *A Treatise concerning the Altercation or Scolding of the Ancients*, and the *Art of Political Lying*.

In the year 1751 there were published two small volumes, entitled *The Miscellaneous Works of Dr Arbuthnot*; but the greater part of what they contain is denied by his son to be of his composition. As it was customary for him, when any comical occurrence took place, which struck his fancy, to write concerning it in a large folio which lay in his parlour, it is very probable that many slight and imperfect essays, which had gone out of his remembrance, might get abroad into the world. Through all his pieces of this kind there runs a vein of good-natured pleasantry; and this tends to confirm the character given of him by Swift, to a lady who desired to know his opinion concerning Dr Arbuthnot, "He has more wit than we all have, and his humanity is equal to his wit." Although his writings are free from that gall and rancour too common among party writers, yet they cannot be said to be altogether free from a party spirit; and in one instance he cannot be excused for allowing his personal dislike to overrule his humanity, viz. in the *Memorandums of the six days preceding the death of a late Right*

Reverend (meaning Bishop Burnet). The indignation of a virtuous man towards an infamous character is sufficient to justify his severity in his bitter *Epitaph on Colonel Chartres*, and this severity was probably aggravated by party spirit. Although he had no proper poetical talent, yet he made an effort to try his genius in that kind of composition. A piece published in Dodsley's collection is valuable for its philosophical sentiment. It is entitled ΓΝΩΘΙ ΣΕΑΥΤΟΝ, *Know thyself*. He was also skilled in music; and Sir J. Hawkins mentions an anthem and a burlesque song which are ascribed to him.

In these occupations he passed his days, amid all the pleasures that can render domestic life happy, in the affection and estimation of his friends, beloved and esteemed by all his literary associates, who have each taken great pains to celebrate their mutual friendship. Swift, in one of his poems, sincerely laments that he is

> Far from his kind Arbuthnot's aid,
> Who knows his art, but not his trade.

Pope has dedicated to him an epistle called a *Prologue to the Satires*. He was full of humility and resignation in all the dispensations of Providence. Of his two sons, he witnessed the death of one; and the other, with some daughters, survived him. At length, from an inveterate asthma, he fell into a dropsical disorder; and, in order to try the effect of a change of air, he repaired to Hampstead, but without the least gleam of hope respecting a recovery, as he assured his friends Pope and Swift. Returning to his house in London, he died February 27, 1734–5.

ARC, Joan of, generally called the *Maid of Orleans*, one of the most famed heroines in the annals of history, was born about the beginning of the 15th century, at Domremy, near Vaucouleurs, in Lorrain, where her father, a peasant, named James d'Arc, resided. When she was able in the least degree to earn a sustenance for herself, her parents, who were but poor, put her to service at a small inn, where she performed several offices more properly belonging to the other sex, such as riding the horses to water without a saddle, and attending them in the fields, and many other similar services, which greatly displayed her masculine habit of body. At the time when Charles VII. was reduced to a very low condition, and the greatest part of his country had been overrun by the English, Joan, probably then at the age of 27 or 28, imagined that she saw several visions, and that in one of these she was commanded by St Michael to go immediately to the relief of Orleans, at that time closely besieged by the English army, and then to procure the consecration of the king at Rheims. In February 1429 her parents took her to the governor of Vaucouleurs, named Baudricourt, who at first held her pretended inspiration to be no more than an idle tale, and treated it with the contempt such a thing would have deserved; but at last, induced by her entreaties, he sent her to Chinon, where the king then was, in order that she might be introduced to him. Charles, whether it proceeded from earnest or not, in order to sound her, determined to present her to a company of his nobles, where no mark of dignity tended to distinguish him from them; and it is asserted that she immediately recognised him, and informed him of secrets which he had endeavoured to conceal from every person. She boldly engaged to accomplish the two objects of her mission, and required that they should arm her with a consecrated sword, which lay in the church of St Catharine of Fierbois; and although she had never seen it, she accurately described every particular concerning it. The manner in which she acted inspired many with confidence; and certain doctors of the church were appointed to examine into the nature of her inspiration, and matrons to give proofs of her virginity. The report which they gave was very favourable; but being next put into the hands of the parliament, they treated her as frantic, and demanded that she should show them a miracle. She answered, that although she had not any at that time to present, she would soon accomplish one at Orleans. At length being fully armed and mounted, she was sent to Orleans along with the army destined for its relief. By displaying a consecrated banner, she soon cleansed the camp of intemperance, and animated the soldiers by her exemplary enthusiasm. Entering Orleans, she introduced a convoy; and boldly attacking the English in their forts, she routed them with great slaughter, and struck them with such a panic that they were even obliged to raise the siege with great precipitation. The dignity of a superior mind and a brave heroism reigned through all her actions. Various other successes followed in a short time, and the dismayed English everywhere fled before the hand of a conquering enemy, whom they had but lately contemned. Joan now thinking it proper to perform her other promise of crowning the king at Rheims, proceeded with him through the kingdom, in order to receive submission of the towns as he marched, which he did without any opposition. Arriving at Rheims, the keys of the city were delivered to him; and, entering the town, he was anointed with the holy oil of Clovis, and crowned, Joan standing by his side in full armour, and displaying her consecrated banner. Charles, filled with gratitude for her important services, ennobled her family, and conferred upon it the title of *the Sys*, with a conformable estate in hand. The two objects of her mission being now accomplished, Joan prepared to retire into the country; but Dunois, the general, being sensible of her importance on account of her pretended inspiration, endeavoured to persuade her to remain in arms until the English should be fully driven from the country; which by his persuasions he effected. Advised by him, she cast herself into Compeigne, then closely besieged by the English and the duke of Burgundy. Having there made a sally upon the enemy, she drove them from their entrenchments; but being basely deserted by her followers, she was taken prisoner. Upon her capture, the English enjoyed a malignant gratification, and resolved to show her no mercy on account of the change she had occasioned in their affairs. The duke of Bedford, the regent, having ransomed her from the captors, appointed a criminal prosecution against her, upon the charges of employing sorcery and magic, and of being impious. He was joined in the accusation by the clergy, and by the university of Paris. She was carried in irons before an ecclesiastical commission at Rouen, where several capricious interrogatories were put to her during a trial of about four months, to which she answered with steadiness and gravity. Among several other questions, she was interrogated why she had assisted at the coronation of Charles with her standard in her hand. She boldly replied, "Because the person who shared in the danger had a right to share in the glory." Her defence was not so strong concerning her pretended inspiration and visions, which were the most dangerous points of the attack. She appealed to the pope upon being accused on these grounds of impiety and heresy, but her appeal was not allowed. At length she was condemned of being a blasphemer and sorceress, and accordingly delivered over to the power of the civil magistrate. A view of the dreadful punishment that awaited her at last overpowered her resolution, and she endeavoured to escape it, by making a disavowal of her pretended revelations, and a full renunciation of her errors. Her sentence was then changed into perpetual imprisonment; but this punishment did not assuage the fury of her barbarous enemies. They

Arc, Joan of || Arch.

craftily laid a man's dress in her chamber; and she, induced by the sight of an apparel in which she had gained so much honour, put it on; and upon being discovered, her enemies condemned her to the stake, interpreting the action into a relapse of heresy. She suffered her punishment in June 1431, at the market-place of Rouen, with great firmness; and even the English themselves beheld the scene with tears. Her death will for ever cast an indelible stigma on the character of her cruel prosecutors. Charles did nothing towards avenging her cause, but ten years afterwards contented himself with procuring the restoration of her memory by the pope, and a reversion of the process. She was styled in that act a "martyr to her religion, her country, and her king." In their enthusiastic admiration, her countrymen were not so slow in honouring her memory. Many marvellous stories were related by them concerning her death. Some supposed that she was not actually dead, and continually expected that, as formerly, she would come, and at their head lead them on to victory. A consistent and uniform judgment respecting the actions and address of this personage cannot be made by posterity. That she gave herself up to the influence of a heated fancy, and that she was confident in the idea of her divine inspiration, and that this notion was so improved by certain favourites of Charles as to excite the emotions of the public, seems to be the most probable supposition. That the appearance of the Maid of Orleans tended to give a decisive turn to the contest between the English and the French, has never in the least been questioned.

ARCADE, in *Architecture*, is used to denote any opening in the wall of a building formed by an arch.

ARCESILAUS, a celebrated Greek philosopher, about 300 years before the Christian era, was born at Pitane, in Eolis. He founded the second academy, called the second or middle school. He was a man of great erudition, and had many disciples. The middle school laid it down as a principle, that we could know nothing, nor even assure ourselves of the certainty of this position; from whence they inferred, that we should affirm nothing, but always suspend our judgment. They advanced, that a philosopher was able to dispute upon every subject, and bring conviction with him, even upon contrary sides of the same question; for there are always reasons of equal force both in the affirmative and negative of every argument. According to this doctrine, neither our senses nor even our reason are to have any credit; and, therefore, in common affairs, we are to conform ourselves to received opinions. Arcesilaus was succeeded by his disciple Lacydes.

ARCH.

Arch defined.

1. Arch, in building, is an artful disposition and adjustment of several stones or bricks, generally in a bow-like form, by which their weight produces a mutual pressure and abutment; so that they not only support each other, and perform the office of an entire lintel, but may be extended to any width, and made to carry the most enormous weights.

History of architecture connected with arches.

2. In those mild climates which seem to have been the first inhabited parts of this globe, mankind stood more in need of shade from the sun than of shelter from the inclemency of the weather. A very small addition to the shade of the woods served them for a dwelling. Sticks laid across from tree to tree, and covered with brushwood and leaves, formed the first houses in those delightful regions. As population and the arts improved, these huts were gradually refined into commodious dwellings. The materials were the same, but more artfully put together. At last agriculture led the inhabitants out of the woods into the open country. The connection between the inhabitant and the soil became now more constant and more interesting. The wish to preserve this connection was natural, and fixed establishments followed of course. Durable buildings were more desirable than those temporary and perishable cottages—stone was substituted for timber.

But as these improved habitations were gradual refinements on the primitive hut, traces of its construction remained, even when the choice of more durable materials made it in some measure inconvenient. Thus it happened, that while a plain building, intended for accommodation only, consisted of walls, pierced with the necessary doors and windows, an ornamented building had, superadded to these essentials, columns, with the whole apparatus of entablature borrowed from the wooden building, of which they had been essential parts, gradually rendered more suitable to the purposes of accommodation and elegance.

3. This view of ornamental architecture will go far to account for some of the more general differences of national style which may be observed in different parts of the world. The Greeks borrowed many of their arts from their Asiatic neighbours, who had cultivated them long before. It is highly probable that architecture travelled from Persia into Greece. In the ruins of Shushan, Persepolis, or Tchelminar, are to be seen the first models of every thing that distinguishes the Grecian architectures. There is no doubt, we suppose, among the learned, as to the great priority of these monuments to any thing that remains in Greece; especially if we take into account the tombs on the mountains, which have every appearance of greater antiquity than the remains of Persepolis. In those tombs we see the whole *ordonnance* of column and entablature, just as they began to deviate from their first and necessary forms in the wooden buildings. We have the architrave, frieze, and cornice; the far-projecting mutules of the Tuscan and Doric orders; the modillions no less distinct; the rudiments of the Ionic capital; the Corinthian capital in perfection, pointing out the very origin of this ornament, viz. a number of long, graceful leaves tied round the head of the column with a fillet (a custom which we know to have been common in their temples and banqueting rooms). Where the distance between the columns is great, so that each had to support a weight too great for one tree, we see the columns clustered or fluted, &c. In short, we see every thing of the Grecian architecture but the sloped roof or pediment—a thing not wanted in a country where it hardly ever rains.

4. The ancient Egyptian architecture seems to be a refinement on the hut built of clay, or unburnt bricks, mixed with straw—every thing is massive, clumsy, and timid—small intercolumniations, and hardly any projections.

5. The Arabian architecture seems a refinement on the tent. A mosque is like a little camp, consisting of a number of little bell tents, stuck close together round a great one. A caravansery is a court surrounded by a row of such tents, each having its own dome. The Greek church of St Sophia at Constantinople has imitated this in some degree; and the copies from it, which have been multiplied in Russia as the sacred form for a Christian church, have added to the original model of clustered tents in the

strictest manner. We are sometimes disposed to think that the painted glass (a fashion brought from the East) was an imitation of the painted hangings of the Arabs.

6. The Chinese architecture is an evident imitation of a wooden building. Sir George Staunton says, that the singular form of their roofs is a *professed* imitation of the cover of a square tent.

In the stone buildings of the Greeks, the roofs were imitations of the wooden ones; hence the lintels, flying cornices, ceilings in compartments, &c.

7. The pediment of the Greeks seems to have suggested the greatest improvement in the art of building. In erecting their small houses, they could hardly fail to observe occasionally, that when two rafters were laid together from the opposite walls, they would, by leaning on each other, give mutual support, as in Plate LII. fig. 1. Nor is it unlikely that such a situation of stones as is represented in fig. 2 would not unfrequently occur by accident to masons. This could hardly fail of exciting a little attention and reflection. It was a pretty obvious reflection, that the stones A and C, by overhanging, leaned against the intermediate stone B, and gave it some support, and that B cannot get down without thrusting aside A and C, or the piers which support them. This was an approach to the theory of an arch; and if this be combined with the observation of fig. 1, we get the disposition represented in fig. 3, having a perpendicular joint in the middle, and the *principle of the arch* is completed. Observe that this is quite different from the principle of the arrangement in fig. 2. In that figure the stones act as wedges, and one cannot get down without thrusting the rest aside. The same principle obtains in fig. 4, consisting of five arch-stones; but in fig. 3 the stones B and C support each other by their mutual pressure (independent of their own weight), arising from the tendency of each lateral pair to fall outwards from the pier. This is the principle of the arch, and would support the key-stone of fig. 4, although each of its joints were perpendicular, by reason of the great friction arising from the horizontal thrust exerted by the adjoining stones.

This was a most important discovery in the art of building; for now a building of any width may be roofed with stone.

8. We are disposed to give the Greeks the merit of this discovery; for we observe arches in the most ancient buildings of Greece, such as the temple of the sun at Athens, and of Apollo at Didymos—not indeed as roofs to any apartment, nor as parts of the ornamental design, but concealed in the walls, covering drains or other necessary openings; and we have not found any *real* arches in any monuments of ancient Persia or Egypt. Sir John Chardin speaks of numerous and extensive subterranean passages at Tchelminar, built of the most exquisite masonry, the joints so exact, and the stones so beautifully dressed, that they look like one continued piece of polished marble; but he nowhere says that they are arched—a circumstance which we think he would not have omitted: no arched door or window is to be seen. Indeed one of the tombs is said to be arch-roofed, but it is all of one solid rock. No trace of an arch is to be seen in the ruins of ancient Egypt; even a wide room is covered with a single block of stone. In the pyramids, indeed, there are two galleries whose roofs consist of many pieces; but their construction puts it beyond doubt that the builder did not know what an arch was; for it is covered in the manner represented in fig. 5, where every projecting piece is more than balanced behind, so that the whole awkward mass could have stood on two pillars. The Greeks, therefore, seem entitled to the honour of the invention. The arched dome, however, seems to have arisen in Etruria, and originated in all probability from the employment of the augurs, whose business it was to observe the flight of birds. Their stations for this purpose were *templa*, so called *a templando*, on the summits of hills. To shelter such a person from the weather, and at the same time allow him a full prospect of the country around him, no building was so proper as a dome set on columns; which accordingly is the figure of a temple in the most ancient monuments of that country. We do not recollect a building of this kind in Greece except that called the *Lanthorn of Demosthenes*, which is of very late date; whereas they abounded in Italy. In the later monuments and coins of Italy or of Rome we commonly find the Etruscan dome and the Grecian temple combined; and the famous Pantheon was of this form, even in its most ancient state.

9. It does not appear that the arch was considered as a part of the *ornamental* architecture of the Greeks during the time of their independency. It is even doubtful whether it was employed in roofing their temples. In none of the *ancient* buildings where the roof is gone can there be seen any rubbish of the vault or mark of the spring of the arch. It is not unfrequent, however, after the Roman conquests, and may be seen in Athens, Delos, Palmyra, Balbeck, and other places. It is very frequent in the magnificent buildings of Rome; such as the Coliseum, the baths of Diocletian, and the triumphal arches, where its form is evidently made the object of attention. But its chief employment was in bridges and aqueducts; and it is in these works that its immense utility is the most conspicuous: for by this happy contrivance a canal or a road may be carried across any stream, where it would be almost impossible to erect piers sufficiently near to each other for carrying lintels. Arches have been executed 130 feet wide, and their execution demonstrates that they may be made four times as wide.

10. As such stupendous arches are the greatest performances of the masonic art, so they are the most difficult and delicate. When we reflect on the immense quantity of materials thus suspended in the air, and compare this with the small cohesion which the firmest cement can give to a building, we shall be convinced that it is not by the force of the cement that they are kept together; they stand fast only in consequence of the proper balance of all their parts. Therefore, in order to erect them with a well-founded confidence of their durability, this balance should be well understood and judiciously employed. We doubt not but that this was understood in some degree by the engineers of antiquity; but they have left us none of their knowledge. They must have had a great deal of mechanical knowledge before they could erect the magnificent and beautiful buildings whose ruins still enchant the world; but they kept it among themselves. We know that the Dionysiacs of Ionia were a great corporation of architects and engineers, who undertook and even monopolized the building of temples, stadiums, and theatres, precisely as the fraternity of masons in the middle ages monopolized the building of cathedrals and conventual churches. Indeed the Dionysiacs resembled the mystical fraternity now called free-masons in many important particulars. They allowed no strangers to interfere in their employment; they recognised each other by signs and tokens; they professed certain mysterious doctrines, under the tuition and tutelage of Bacchus, to whom they built a magnificent temple at Teos, where they celebrated his mysteries as solemn festivals; and they called all other men profane because not admitted to these mysteries. But their chief mysteries and most important secrets seem to be their mechanical and mathematical sciences, or all that academical knowledge which forms the regular education of a civil engineer.

Arch.

We know that the temples of the gods and the theatres required an immense apparatus of machinery for the celebration of some of their mysteries; and that the Dionysiacs contracted for those jobs, even at far distant places, where they had not the privilege of building the edifice which was to contain them. This is the most likely way of explaining the very small quantity of mechanical knowledge that is to be met with in the writings of the ancients. Even Vitruvius does not appear to have been of the fraternity, and speaks of the Greek architects in terms of respect next to veneration. The *Collegium Murariorum*, or incorporation of masons at Rome, does not seem to have shared the secrets of the Dionysiacs.

11. The art of building arches has been most assiduously cultivated by the associated builders of the middle ages of the Christian church, both Saracens and Christians, and they seem to have indulged in it with fondness: they multiplied and combined arches without end, placing them in every possible situation.

12. Having studied this branch of the art of building with so much attention, they were able to erect the most magnificent buildings with materials which a Greek or Roman architect could have made little or no use of. There is infinitely more scientific skill displayed in a Gothic cathedral than in all the buildings of Greece and Rome. Indeed these last exhibit very little knowledge of the mutual balance of arches, and are full of gross blunders in this respect; nor could they have resisted the shock of time so long, had they not been almost solid masses of stone, with no more cavity than was indispensably necessary.

13. Anthemius and Isidorus, whom the Emperor Justinian had selected as the most eminent architects of Greece, for building the celebrated church of St Sophia at Constantinople, seem to have known very little of this matter. Anthemius had boasted to Justinian that he would outdo the magnificence of the Roman Pantheon, for he would hang a greater dome than it aloft in the air. Accordingly he attempted to raise it on the heads of four piers, distant from each other about 115 feet, and about the same height. He had probably seen the magnificent vaultings of the temple of Mars the Avenger, and the temple of Peace at Rome, the thrusts of which are withstood by two masses of solid wall, which join the side walls of the temple at right angles, and extend sidewise to a great distance. It was evident that the walls of the temple could not yield to the pressure of the vaulting without pushing these immense buttresses along their foundations. He therefore placed four buttresses to aid his piers. They are almost solid masses of stone, extending at least ninety feet from the piers to the north and to the south, forming as it were the side walls of the cross. They effectually secured them from the thrusts of the two great arches of the nave which support the dome; but there was no such provision against the push of the great north and south arches. Anthemius trusted for this to the half dome which covered the semicircular east end of the church, and occupied the whole eastern arch of the great dome. But when the dome was finished, and had stood a few months, it pushed the two eastern piers with their buttresses from the perpendicular, making them lean to the eastward, and the dome and half dome fell in. Isidorus, who succeeded to the charge on the death of Anthemius, strengthened the piers on the east side by filling up some hollows, and again raised the dome. But things gave way before it was closed; and while they were building in one part, it was falling in in another. The pillars and walls of the eastern semicircular end were much shattered by this time. Isidorus seeing that they could give no resistance to the push which was so evidently directed that way, erected some clumsy buttresses on the east wall of the square which surrounded the whole Greek cross, and was roofed in with it, forming a sort of cloister round the whole. These buttresses, spanning over this cloister, leaned against the piers of the dome, and thus opposed the thrusts of the great north and south arches. The dome was now turned for the third time, and many contrivances were adopted for making it extremely light. It was made offensively flat, and, except the ribs, was roofed with pumice stone; but, notwithstanding these precautions, the arches settled so as to alarm the architects, and they made all sure by filling up the whole from top to bottom with arcades in three stories. The lowest arcade was very lofty, supported by four noble marble columns, and thus preserved in some measure the church in the form of a Greek cross. The story above formed a gallery for the women, and had six columns in front, so that they did not bear fair on those below. The third story was a dead wall filling up the arch, and pierced with three rows of small, ill-shaped windows. In this unworkmanlike shape it has stood till now, and is the oldest church in the world; but it is an ugly mis-shapen mass, more resembling an overgrown potter's kiln, surrounded with furnaces pierced and patched, than a magnificent temple. We have been thus particular in our account of it, because this history of the building shows that the ancient architects had acquired no distinct notions of the action of arches. Almost any mason of our time would know, that as the south arch would push the pier to the eastward, while the east arch pushed it to the southward, the buttress which was to withstand these thrusts must not be placed on the south side of the pier, but on the south-east side, or that there must be an eastern as well as a southern buttress.

14. No such blunders are to be seen in a Gothic cathedral. Some of them appear, to a careless spectator, to be very massive and clumsy; but when judiciously examined, they will be found very bold and light, being pierced in every direction by arcades; and the walls are divided into cells like a honeycomb, so that they are very stiff, while they are very light.

15. About the middle, or rather towards the end, of last century, when the Newtonian mathematics opened the road to true mechanical science, the construction of arches engrossed the attention of the first mathematicians. The first hint of a principle that we have met with is Dr Hooke's assertion, that the figure into which a chain or rope, perfectly flexible, will arrange itself when suspended from two hooks, is, when inverted, the proper form for an arch composed of stones of uniform weight. This he affirmed on the principle, that the figure which a flexible festoon of heavy bodies assumes, when suspended from two points, is, when inverted, the proper form of an arch of the same bodies, touching each other in the same points; because the force with which they mutually press on each other in this last case are equal and opposite to the forces with which they pull at each other in the case of suspension.

Dr H's prin of arch

This principle is strictly just, and may be extended to every case which can be proposed. We recollect seeing it proposed in very general terms in 1759, when plans were forming for Blackfriars Bridge in London; and since it is perhaps equal in practical utility to the most elaborate investigations of the mathematicians, our readers will not be displeased with a more particular account of it in this place.

16. Let ABC (fig. 6) be a parcel of magnets of any size and shape, and let us suppose that they adhere with great force by any points of contact. They will compose such a flexible festoon as we have been speaking of if

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suspended from the points A and C. If this figure be inverted, preserving the same points of contact, they will remain in equilibrio. It will indeed be that kind of equilibrium which will admit of no disturbance, and which may be called a *tottering equilibrium*. If the form be altered in the smallest degree, by varying the points of contact (which indeed are points in the *figure of equilibration*), the magnets will no more recover their former position than a needle, which we had made to stand on its point, will regain its perpendicular position after it has been disturbed.

But if we suppose planes *d e*, *f g*, *h i*, &c. drawn through the points of mutual contact *a*, *b*, *c*, each bisecting the angle formed by the lines that unite the adjoining contacts (*f g*, for example, bisecting the angle formed by *a b*, *b c*), and if we suppose that the pieces are changed for others of the same weights, but having flat sides, which meet in the planes *d e*, *f g*, *h i*, &c., it is evident that we shall have an arch of equilibration, and that the arch will have some stability, or will bear a little change of form without tumbling down: for it is plain that the equilibrium of the original festoon obtained only in the points *a*, *b*, *c*, of contact, where the pressures were perpendicular to the touching surfaces; therefore, if the curve *a*, *b*, *c*, still passes through the touching surfaces perpendicularly, the conditions that are required for equilibrium still obtain. The case is quite similar to that of the stability of a body resting on a horizontal plane. If the perpendicular through the centre of gravity falls within the base of the body, it will not only stand, but it will require some force to push it over. In the original festoon, if a small weight be added in any part, it will change the form of the curve of equilibration a little, by changing the points of mutual contact. This new curve will gradually separate from the former curve as it recedes from A or C. In like manner, when the festoon is set up as an arch, if a small weight be laid on any part of it, it will bring the whole to the ground, because the shifting of the points of contact will be just the contrary to what it should be to suit the new curve of equilibration; but if the same weight be laid on the same part of the arch now constructed with flat joints, it will be sustained if the new curve of equilibration still passes through the touching surfaces.

17. These conclusions, which are very obviously deducible from the principle of the festoon, show us, without any further discussion, that the longer the joints are, the greater will be the stability of the arch, or that it will require a greater force to break it down. Therefore it is of the greatest importance to have the arch-stones as long as economy will permit; and this was the great use of the ribs and other apparent ornaments in the Gothic architecture. The great projections of those ribs augmented their stiffness, and enabled them to support the unadorned compartments of the roof, composed of very small stones, seldom above six inches thick. Many old bridges are still remaining, which are strengthened in the same way by ribs.

Having thus explained, in a very familiar manner, the stability of an arch, we proceed to give the same popular account of the general application of the principle.

18. Suppose it be required to ascertain the form of an arch which shall have the span AB (fig. 7), and the height F8, and which shall have a road-way of the dimensions CDE above it. Let the figure ACDEB be inverted, so as to form a figure A*cde*B. Let a chain of uniform thickness be suspended from the points A and B, and let it be of such a length that its lower point will hang at, or rather a little below, *f*, corresponding to F. Divide AB into a number of equal parts, in the points 1, 2, 3, &c. and draw vertical lines, cutting the chain in the corresponding points 1, 2, 3, &c. Now take pieces of another chain, and hang them on at the points 1, 2, 3, &c. of the chain A*f*B. This will alter the form of the curve. Cut or trim these pieces of chain, till their lower ends all coincide with the inverted road-way *c d e*. The greater lengths that are hung on in the vicinity of A and B will pull down these points of the chain, and cause the middle point *f* (which is less loaded) to rise a little, and will bring it near to its proper height.

It is plain that this process will produce an arch of perfect equilibration; but some further considerations are necessary for making it exactly suit our purpose. It is an arch of equilibration for a bridge that is so loaded that the weight of the arch-stones is to the weight of the matter with which the haunches and crown are loaded, as the weight of the chain A*f*B is to the sum of the weights of all the little bits of chain very nearly. But this proportion is not known beforehand; we must therefore proceed in the following manner:—Adapt to the curve produced in this way a thickness of the arch-stones as great as are thought sufficient to insure stability; then compute the weight of the arch-stones, and the weight of the gravel or rubbish with which the haunches are to be filled up to the road-way. If the proportion of these two weights be the same with the proportion of the weights of chain, we may rest satisfied with the curve now found; but if different, we can easily calculate how much must be added equally to or taken from each appended bit of chain, in order to make the two proportions equal. Having altered the appended pieces accordingly, we shall get a new curve, which may perhaps require a very small trimming of the bits of chain to make them fit the road-way. This curve will be very near to the curve wanted.

We have practised this method for an arch of 60 feet span and 21 feet high, the arch-stones of which were only two feet nine inches long. It was to be loaded with gravel and shivers. We made a previous computation, on the supposition that the arch was to be nearly elliptical. The distance between the points 1, 2, 3, &c. were adjusted, so as to determine the proportion of the weights of chain agreeable to the supposition. The curve differed considerably from an ellipse, making a considerable angle with the verticals at the spring of the arch. The real proportion of the weights of chain, when all was trimmed so as to suit the road-way, was considerably different from what was expected. It was adjusted. The adjustment made very little change in the curve. It would not have changed it two inches in any part of the real arch. When the process was completed, we constructed the curve mathematically. It did not differ sensibly from this mechanical construction. This was very agreeable information; for it showed us that the first curve, formed by about two hours' labour, on a supposition considerably different from the truth, would have been sufficiently exact for the purpose, being in no place three inches from the accurate curve, and therefore far within the joints of the intended arch-stones. Therefore this process, which any intelligent mason, though ignorant of mathematical science, may go through with little trouble, will give a very proper form for an arch subject to any conditions.

19. The chief defect of the curve found in this way is a want of elegance, because it does not spring at right angles to the horizontal line; but this is the case with all curves of equilibration, as we shall see by and by. It is not material; for, in the very neighbourhood of the piers, we may give it any form we please, because the masonry is solid in that place; nay, we apprehend that a deviation from the curve of equilibration is proper. The construction of that curve supposes that the pressure on every part of the arch is vertical; but gravel, earth, and rub-

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bish, exert somewhat of a hydrostatical pressure laterally in the act of settling, and retain it afterwards. This will require some more curvature at the haunches of an arch to balance it; but what this lateral pressure may be, cannot be deduced with confidence from any experiments that we have seen. We are inclined to think, that if, instead of dividing the horizontal line AB in the points 1, 2, 3, &c. we divide the chain itself into equal parts, the curve will approach nearer to the proper form.

Theory founded on this principle.

20. After this familiar statement of the general principle, it is now time to consider the theory founded on it more in detail. This theory aims at such an adjustment of the position of the arch-stones to the load on every part of the arch, that all shall remain in equilibrio, although the joints be perfectly polished and without any cement. The whole may be reduced to two problems. The first is to determine the vertical pressure or load on every point of a line of a given form, which will put that line in equilibrio. The second is to determine the form of a curve which shall be in equilibrio when loaded in its different points, according to any given law.

The whole theory is deducible from one principle, which will be found fully developed in the article Roof. It is this: when an assemblage of beams or other pieces of solid matter AB, BC, CD, DE, fig. 8, freely movable about its angles as so many joints, is retained in equilibrium by the joint effect of the pressures produced by the weight of its parts, the thrust at any angle, if estimated in a horizontal direction, is the same throughout, and may be represented by any horizontal line BT; and that if a vertical line QS be drawn through T, the thrust exerted at any angle D by the piece CD, in its own direction, will then be represented by BR, drawn parallel to CD; and in like manner, that the thrust in the direction ED is represented by BS, &c.; and, lastly, that the vertical thrust or loads at each angle B, C, D, by which all these other pressures are excited, are represented by the portions QC, CR, RS, of the vertical intercepted by those lines; that is, all these pressures are to the uniform horizontal thrust as the lines which represent them are to BT. The horizontal thrust, therefore, is a very proper unit, with which we may compare all the others. Its magnitude is easily deduced from the same proposition; for QS is the sum of all the vertical pressures of the angles, and therefore represents the weight of the whole assemblage. Therefore as QS is to BT, so is the weight of the whole to the horizontal thrust.

21. To accommodate this theory to the construction of a curvilinear arch vault, let us first suppose the vault to be polygonal, composed of the chords of the elementary arches. Let AVE (fig. 12) be a curvilinear arch, of which V is the vertex, and VX the vertical axis, which we shall consider as the axis or abscissa of the curve, while any horizontal line, such as HK, is an ordinate to the curve. About any point C of the curve, as a centre, describe a circle BLD, cutting the curve in B and D. Draw the equal chords CB, CD. Draw also the horizontal line CF, cutting the circle in F. Describe a circle BCDQ passing through B, C, D. Its centre O will be in a line COQ, which bisects the angle BCD; and C c, which touches this circle in C, will bisect the angle b C d, formed by the equal chords BC, CD. Draw CLP perpendicular to cb, and DP perpendicular to CD, meeting CL in P. Through L draw the tangent GLM, meeting CD in G, and the vertical line CM in M. Draw the tangent Fa, cutting the chords BC, CD, in b and d, and the tangent to the circle BCDQ in c. Lastly, draw d N parallel to bc.

From what will be demonstrated in the article Roof, it appears that if BC, CD be two pieces of an equilibrated heavy polygon, and if CF represent the horizontal thrust in every angle of the polygon, C d and C b will severally represent the thrusts exerted by the pieces DC, BC, and that bd, or CN, will represent the weight lying on the angle BCD, by which those thrusts are balanced. In the mean time the reader may, without that article, understand the nature of the equilibrium in the following manner. Produce d C to o, so that C o may be equal to C d. Draw bn to the vertical parallel to d C, and join no. It is evident that bnoC is a parallelogram, and that n C $(= bd)$ = CN. Now the thrust or support of the piece BC is exerted in the direction C b, while that of DC is exerted in the direction C o. These two thrusts are equivalent to the thrust in the diagonal C n; and it is with this compound thrust that the load or vertical pressure CN is in *immediate* equilibrium.

22. Because bCL, NCF are right angles, and FCL is common to both, the angles bCF and MCL are equal; therefore the right-angled triangles bCF and MCL are similar. And since CF is equal to CL, Cb is equal to CM. It is evident that the triangles GCM and dCN are similar. Therefore CG : Cd = CM : CN = C b : C N. Therefore we have $CN = \frac{Cb \times Cd}{CG}$. But because CDP and CLG are right angles, and therefore equal, and the angle GCP is common to the two triangles GCL, PCD, and CD is equal to CL, we have CG equal to CP; therefore CN $= \frac{Cb \times Cd}{CP}$. Also, since CDP is a right angle, DP meets the diameter in Q, the opposite point of the circumference, and the angle DQC is equal to DCc or cCb (because bCd is bisected by the tangent), that is, to PCQ (because the right angles bCP, cCO are equal, and cDP is common). Therefore PQ is equal to PC; and if PO be drawn perpendicular to CQ, it will bisect it, and O is the centre of the circle BCDQB.

Now let the points B and D continually approach to C (by diminishing the radius of the small circle), and ultimately coincide with it. It is evident that the circle BCDQ is ultimately the equicurve circle, and that PC ultimately coincides with OC, the radius of curvature. Also $Cb \times Cd$ becomes ultimately Cc^2. Therefore CN, the vertical load on any point of a curve of equilibration, is $= \frac{Cc^2}{\text{Rad. Curv.}}$.

It is further evident that CF is to Cc as radius to the secant of the elevation of the tangent above the horizon. Therefore we have the load on any point of the curve always proportional to $\frac{\text{Sec.}^2\ \text{Elev.}}{\text{Rad. Curv.}}$.

This load on every elementary arch of the wall is commonly a quantity of solid matter incumbent on that element of the curve, and pressing it vertically; and it may be conceived as made up of a number of heavy lines standing vertically on it. Thus, if the element Ee of the curve were lying horizontally, a little parallelogram REer standing perpendicularly on it would represent its load. But as this element Ee has a sloping position, it is plain that, in order to have the same quantity of heavy matter pressing it vertically, the height of the parallelogram must be increased till it meets in ε, the line Rε drawn parallel to the tangent EG. It is evident that the angle REε is equal to the angle AEG. Therefore we have ER : Eε = Rad. : Sec. Elev.

If therefore the arch is kept in equilibrio by the vertical pressure of a wall, we must have the height of the wall above any point proportional to $\frac{\text{Sec.}^3\ \text{Elev.}}{\text{Rad. of Curv.}}$.

23. *Corol.* 1. If OS be drawn perpendicular to the Cor

vertical CS, CS will be half the vertical chord of the equicurve circle. The angle OCS is equal to cCF, that is, to the angle of elevation. Therefore 1 : Sec. Elev. = CS : CO, and the secant of elevation may be expressed by $\frac{CO}{CS}$, and its cube by $\frac{CO^3}{CS^3}$. Therefore the height of wall is proportional to $\frac{CO^3}{CS^3 \times CO}$, or to $\frac{CO^2}{CS^3}$, or $\frac{CO^2}{CS^2 \times CS}$, or to $\frac{\text{Sec.}^2 \text{ of Elev.}}{\text{Vert. Chord of Curve}}$.

Corol. 2. If we make the arch VC $= z$, the abscissa VH $= x$, the ordinate HC $= y$, the radius osculi CO $= r$, and the $\frac{1}{2}$ vertical chord CS $= s$, the height of wall pressing on any point is proportional to $\frac{dz^3}{rdy^3}$; or to $\frac{dz^2}{sdy^2}$, or $\frac{dx^2 + dy^2}{sdy^2}$. Therefore, when the equation of the curve is given, and the height of wall on any one point of it is also given, we can determine it for any other point; for the equation of the curve will always give us the relation of dz, dx, dy, and the value of r or s. This may be illustrated by an example or two. For this purpose it will generally be most convenient to assume the height above the vertex V for the unit of computation. The thickness of the arch at the crown is commonly determined by other circumstances. At the vertex the tangent to the arch is horizontal, and therefore the cube of the secant is unity, or 1. Call the height of wall at the crown H, and let the radius of curvature in that point be R, and its half-chord R (it being then coincident with the radius), and the height on any other point h; we have $\frac{1}{R} : \frac{dz^3}{rdy^3} = H : h$, and $h = H \times \frac{dz^3}{dy^3} \times \frac{R}{r}$. The other formula gives $h = H \times \frac{dz^2}{dy^2} \times \frac{R}{s}$.

24. *Ex.* 1. Suppose the arch to be a segment of a circle, as in fig. 10, where AE is the diameter, and O the centre. In this arch the curvature is the same throughout, or $\frac{R}{r} = 1$. Therefore $h = H \times \frac{dz^3}{dy^3}$, or $= H \times$ Cube Sec. Elev.

This gives a very simple calculus. To the logarithm of H add thrice the logarithm of the secant of elevation. The sum is the logarithm of h.

It gives also a very simple construction. Draw the vertical CS, cutting the horizontal diameter in S. Draw ST, cutting the radius OC perpendicularly in T. Draw the horizontal line Tz, cutting the vertical in z. Join zO. Make Cu = Vv, and draw ux parallel to zO : Cc must be made = Cx. The demonstration is evident.

It is very easy to see that if CV is an arch of 60°, and Vv is $\frac{1}{14}$th of VO, the points v and c will be on a level; for the secant of CV is twice CO, and therefore Cc is eight times Vv, which is $\frac{1}{7}$th of VH.

The dotted line $vgcf$ is drawn according to this calculus or construction. It falls considerably below the horizontal line in the neighbourhood of c; and then, passing very obliquely through c, it rises rapidly to an immeasurable height, because the vertical line through A is its asymptote. This must evidently be the case with every curve which springs at right angles with a horizontal line.

It is plain that if vV be greater, all the other ordinates of the curve $vgcf$, resting on the circumference AVE, will be greater in the same proportion, and the curve will cut the horizontal line drawn through v in some point nearer to v than c is. Hence it appears that a circular arch cannot be put in equilibrio by building on it up to a horizontal line, whatever be its span, or whatever be the thickness at the crown. We have seen that when this thickness is only $\frac{1}{14}$th of the radius, an arch of 120 degrees will be too much loaded at the flanks. This thickness is much too small for a bridge, being only $\frac{1}{25}$th of the span CM, whereas it should have been almost double of this, to bear the inequalities of weight that may occasionally be on it. When the crown is made still thinner, the outline is still more depressed before it rises again. There is therefore a certain span, with a corresponding thickness at the crown, which will deviate least of all from a horizontal line. This is an arch of about 45 degrees, the thickness at the crown being about one fourth of the span, which is extravagantly great. It appears in general, therefore, that the circle is not a curve suited to the purposes of a bridge or an arcade, which requires an outline nearly horizontal.

Ex. 2. Let the curve be a parabola AVE (fig. 14), of which V is the vertex, and DG the directrix. Draw the diameters DCF, GVN, the tangents CK, VP, and the ordinates VF and CN. It is well known that GV is to DC as VP^2 to CK^2, or as CN^2 to CK^2. Also 2 GV is the radius of the osculating circle at V, and 2 DC is one half of the vertical chord of the osculating circle at C.

Therefore $CN^2 : CK^2$ (or $dy^2 : dz^2$) $= R : s$; and $s = \frac{dz^2}{dy^2} R$. But Cc, or $h = H \times \frac{dz^2 R}{dy^2 s}$. Therefore $h = H \times \frac{dz^2 R}{dy^2 \frac{dz^2}{dy^2} R} = H \times \frac{dz^2 R}{dz^2 R} = H$. Therefore C$c$ = vV.

It follows from this investigation, that the back or extrados of a parabolic arch of equilibration must be parallel to the arch or soffit itself; or that the thickness of the arch, estimated in a vertical direction, must be equal throughout; or that the extrados is the same parabola with the soffit or intrados.

We have selected these two examples merely for the simplicity and perspicuity of the solutions, which have been effected by means of elementary geometry only, instead of employing the analytical value of the radius of the osculatory circle, viz. $\frac{dz^3}{dyd^2x - dxd^2y}$, which would have involved us at last in the doctrine of second fluxions. We have also preferred simplicity to elegance in the investigation, because we wish to instruct the practical engineer who may not be a proficient in the higher mathematics.

25. The converse of the problem, namely, to find the form of the arch when the figure of the back of it is given, is the most usual question of the two, at least in cases which are most important and most difficult. Of these, perhaps, bridges are the chief. Here the necessity of a road-way, of easy and regular ascent, confines us to an outline nearly horizontal, to which the curve of the arch must be adapted. This is the most difficult problem of the two; and we doubt whether it can be solved without employing infinite approximating series instead of accurate values.

To find the form of an arch when the figure of its back is given.

Let *ave* (fig. 9) be the intended outline or extrados of the arch AVE, and let vQ be the common axis of both curves. From c and C, the corresponding points, draw the ordinates ch, CH. Let the thickness vV at the top be a, the abscissa vh be $= u$, and VH $= x$, and let the equal ordinates ch, CH, be y, and the arch VC be z.

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Then, by the general theorem, $cC = \frac{dz^3}{rdy^3}$, r being the radius of curvature. This, by the common rules, is $= \frac{dz^3}{dyd^2x - dxd^2y}$. This gives us $cC \doteqdot \frac{dyd^2x - dxd^2y}{dy^3}$, or $= \frac{dyd^2x - dxd^2y}{dy^3} \times C$; where C is a constant quantity, found by taking the real value of cC in V, the vertex of the curve. But it is evident that it is also $= a + x - u$. Therefore $a + x - u = \frac{dyd^2x - dxd^2y}{dy^3} \times C = \frac{C}{dy} \times$ fluxion of $\frac{dx}{dy}$.

If we now substitute the true value of u (which is given because the extrados is supposed to be of a known form), expressed in terms of y, the resulting equation will contain nothing but x and y, with their first and second fluxions, and known quantities. From this equation the relation of x and y must be found by such methods as seem best adapted to the equation of the extrados.

Fortunately the process is more simple and easy in the most common and useful case than we should expect from this general rule; we mean the case where the extrados is a straight line, especially when this is horizontal. In this case u is equal to o.

Pl. LIII. fig. 6. *Ex.* To find the form of the balanced arch AVE, having the horizontal line cv for its extrados.

Keeping the same notation, we have $u = o$, and therefore

$$a + x = \frac{C}{dy} \times \text{fluxion of } \frac{dx}{dy}.$$

Assume $dy = \frac{dx}{v}$; then $\frac{dx}{dy} = v$, and $\frac{C}{dy} \times$ fluxion of $\frac{dx}{dy} = \frac{Cvdv}{dx}$, that is, $a + x = \frac{Cvdv}{dx}$. Therefore $adx + xdx = Cvdv$; and by taking the fluents, we have $2\,ax + x^2 = Cv^2$; and $v = \sqrt{\frac{2\,ax + x^2}{C}}$. Consequently, $dy = \frac{\sqrt{Cdx}}{\sqrt{2\,ax + x^2}}$ $\left(\text{being} = \frac{dx}{v}\right)$. Taking the fluent of this, we have $y = \sqrt{C} \times L\,(2\,a + 2\,x + 2\sqrt{2\,ax + x^2})$. But at the vertex, where $x = o$, we have $y = \sqrt{C} \times L\,(2\,a)$. The corrected fluent is therefore $y = \sqrt{C} \times L\frac{a + x + \sqrt{2\,ax + x^2}}{a}$.

It only remains to find the constant quantity C. This we readily obtain by selecting some point of the extrados where the values of x and y are given by particular circumstances of the case. Thus, when the span $2\,s$ and height h of the arch are given, we have

$s = \sqrt{C} \times L\left(\frac{a + h + \sqrt{2\,ah + h^2}}{a}\right)$, and consequently $\sqrt{C} = \frac{s}{L\left(\frac{a + h + \sqrt{2\,ah + h^2}}{a}\right)}$. Therefore the general value of

$$y = s \times \frac{L\left(\frac{a + x + \sqrt{2\,ax + x^2}}{a}\right)}{L\left(\frac{a + h + \sqrt{2\,ah + h^2}}{a}\right)}$$

$$= \frac{s}{L\frac{a + h + \sqrt{(2ah + h^2)}}{a}} \times L\frac{a + x + \sqrt{2\,ax + a^2}}{a}.$$

26. As an example of the use of this formula, we subjoin a table calculated by Dr Hutton of Woolwich, for an arch, the span of which is 100 feet, and the height 40, which are nearly the dimensions of the middle arch of Blackfriars Bridge in London.

y	x	y	x	y	x
0	6,000	21	10,381	36	21,774
2	6,035	22	10,858	37	22,948
4	6,144	23	11,368	38	24,190
6	6,324	24	11,911	39	25,505
8	6,580	25	12,489	40	26,894
10	6,914	26	13,106	41	28,364
12	7,330	27	13,761	42	29,919
13	7,571	28	14,457	43	31,563
14	7,834	29	15,196	44	33,299
15	8,120	30	15,980	45	35,135
16	8,430	31	16,811	46	37,075
17	8,766	32	17,693	47	39,126
18	9,168	33	18,627	48	41,293
19	9,517	34	19,617	49	43,581
20	9,934	35	20,665	50	46,000

The figure for this proposition is exactly drawn according to these dimensions, that the reader may judge of it as an object of sight. It is by no means deficient in gracefulness, and is abundantly roomy for the passage of craft; so that no objection can be offered against its being adapted on account of its mechanical excellency.

The reader will perhaps be surprised that we have made no mention of the celebrated Catenarean curve, which is commonly said to be the best form for an arch; but a little reflection will convince him, that although it is the only form for an arch consisting of stones of equal weight, and touching each other only in single points, it cannot suit an arch which must be filled up in the haunches, in order to form a road-way. He will be more surprised to hear, after this, that there is a certain thickness at the crown, which will put the Catenarea in equilibrio, even with a horizontal road-way; but this thickness is so great as to make it unfit for a bridge, being such that the pressure at the vertex is equal to the horizontal thrust. This would have been about 37 feet in the middle arch of Blackfriars Bridge. The only situation, therefore, in which the Catenarean form would be proper, is an arcade carrying a height of dead wall; but in this situation it would be very ungraceful. Without troubling the reader with the investigation, it is sufficient to inform him, that in a Catenarean arch of equilibration the abscissa VH is to the abscissa $v\,h$ in the constant ratio of the horizontal thrust to its excess above the pressure on the vertex

27. Thus much will serve, we hope, to give the reader a clear notion of this celebrated theory of the equilibrium of arches, one of the most delicate and important applications of mathematical science. Volumes have been written on the subject, and it still occupies the attention of mechanicians. But we beg leave to say, with great deference to the eminent persons who have prosecuted this theory, that their speculations have been of little service, and are little attended to by the practitioner. Nay, we may add, that Sir Christopher Wren, perhaps the most accomplished architect that Europe has seen, seems to have thought it of little value; for, among the fragments which have been preserved of his studies, there are to be seen some imperfect dissertations on this very subject, in which he takes no notice of this theory, and considers the balance of arches in quite another way. These are collected by the author of the account of Sir Christopher Wren's family. This man's great sagacity,

and his great experience in building, and still more his experience in the repairs of old and crazy fabrics, had shown him many things very inconsistent with this theory, which appears so specious and safe. The general facts which occur in the failure of old arches are highly instructive, and deserve the most careful attention of the engineer; for it is in this state that their defects, and the process of nature in their destruction, are most distinctly seen. We venture to affirm, that a very great majority of these facts are irreconcilable to the theory. The way in which circular arches commonly fail, is by the sinking of the crown and the rising of the flanks. It will be found by calculation, that in most of the cases it ought to have been just the contrary. But the clearest proof is, that arches very rarely fail where their load differs most remarkably from that which this theory allows. Semicircular arches have stood the power of ages, as may be seen in the bridges of ancient Rome, and in the numerous arcades which the ancient inhabitants have erected. Now, all arches which spring perpendicularly from the horizontal line require, by this theory, a load of infinite height; and even to a considerable distance from the springing of the arch, the load necessary for the theoretical equilibrium is many times greater than what is ever laid on those parts; yet a failure in the immediate neighbourhood of the spring of an arch is a most rare phenomenon, if it ever was observed. Here is a most remarkable deviation from the theory; for, as is already observed, the load is frequently not the fourth part of what the theory requires.

28. Many other facts might be adduced which show great deviation from the legitimate results of the theory. We hope to be excused, therefore, by the mathematicians for doubting of the justness of this theory. We do not think it erroneous, but defective, leaving out circumstances which we apprehend to be of great importance; and we imagine that the defects of the theory have arisen from the very anxiety of the mechanicians to make it perfect. The arch-stones are supposed to be perfectly smooth or polished, and not to be connected by any cement, and therefore to sustain each other merely by the equilibrium of their vertical pressure. The theory insures this equilibrium, and this only, leaving unnoticed any other causes of mutual action.

The authors who have written on the subject say expressly that an arch which thus sustains itself must be stronger than another which would not; because when, in imagination, we suppose both to acquire connection by cement, the first preserves the influence of this connection unimpaired; whereas in the other, part of the cohesion is wasted in counteracting the tendency of some parts to break off from the rest by their want of equilibrium. This is a very specious argument, and would be just, if the forces which are mutually exerted between the parts of the arch in its settled state were merely vertical pressures, or, where different, were inconsiderable in comparison with those which are really attended to in the construction.

But this is by no means the case. The forms which the uses for which arches are erected oblige us to adopt, and the loads laid on the different points of the arch, frequently deviate considerably from what are necessary for the equilibrium of vertical pressures. The varying load on a bridge, when a great waggon passes along it, sometimes bears a very sensible proportion to the weight of that point of the arch on which it rests. It is even very doubtful whether the pressures which are occasioned by the weight of the stuff employed for filling up the flanks really act in a vertical direction, and in the proportion which is supposed. We are pretty certain that this is not the case with sand, gravel, fat mould, and many substances in very general use for this purpose. When this is the case, the pressures sustained by the different parts of the arch are often very inconsistent with the theory; a part of the arch is overloaded and tends to fall in, but is prevented by the cement. This part of the arch, therefore, acts on the remoter parts by the intervention of the parts between, employing those intermediate parts as a kind of levers to break the arch in a remote part, just as a lintel would be broken. We apprehend that a mathematician would be puzzled how to explain the stability of an arch cut out of a solid and uniform mass of rock. His theory considers the mutual thrusts of the arch-stones as in the direction of the tangents to the arch. Why so? Because he supposes that all his polished joints are perpendicular to those tangents. But in the present case he has no existing joints; and there seems to be nothing to direct his imagination in the assumption of joints, which, however, are absolutely necessary for employing his theory, because, without a supposition of this kind, there seems no conceiving any mutual abutment of the arch-stones. Ask a common but intelligent mason, what notion he forms of such an arch? We apprehend that he will consider it as no arch, but as a lintel, which may be broken like a wooden lintel, and which resists entirely by its cohesion. He will not readily conceive that, by cutting the under side of a stone lintel into an arched form, and thus taking away more than half of its substance, he has changed its nature of a lintel, or given it any additional strength. Nor would there be any change made in the way in which such a mass of stone would resist being broken down, if nothing were done but forming the under side into an arch. If the lintel be so laid on the piers that it can be broken without its parts pushing the piers aside (which will be the case if it lies on the piers with horizontal joints), it will break like any other lintel; but if the joints are directed downwards, and converging to a point within the arch, the broken stone (suppose it broken at the crown by an overload in that part) cannot be pressed down without forcing the piers outwards. Now, in this mode of acting, the mind cannot trace any thing of the statical equilibrium that we have proceeded on in the foregoing theory. The two parts of the broken lintel seem to push the piers aside in the same manner that two rafters push outwards the walls of a house when their feet are not held together by a tie-beam. If the piers cannot be pushed aside (as when the arch abuts on two solid rocks), nothing can press down the crown which does not crush the stone.

This conclusion will be strictly true if the arch is of such a form that a straight line drawn from the crown to the pier lies wholly within the solid masonry. Thus, if the vault consist of two straight stones, as in Plate LII. fig. 1, or if it consist of several stones, as in Plate LIII. fig. 7, disposed in two straight lines, no weight laid on the crown can destroy it in any other way than by crushing it to powder.

29. But when straight lines cannot be drawn from the overloaded part to the firm abutments through the solid masonry, and when the cohesion of the parts is not able to withstand the transverse strains, we must call the principles of equilibrium to our aid; and, in order to employ them with safety, we must consider how they are modified by the excitement of the cohering forces.

The cohesion of the stones with each other by cement or otherwise has in almost every situation a bad effect. It enables an overload at the crown to break the arch near the haunches, causing those parts to rise, and then to spread outwards, just as a Mansarde or Kirb roof would do if the truss-beam which connects the heads of the lower rafters were sawn through. This can be prevented

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only by loading that part more than is requisite for equilibrium. It would be prudent to do this to a certain degree, because it is by this cohesion that the crown always becomes the weakest part of the arch, and suffers more by any occasional load.

We expect that it will be said in answer to all this, that the cohesion given by the strongest cement that we can employ, nay the cohesion of the stone itself, is a mere nothing in comparison with the enormous thrusts that are in a state of continual exertion in the different parts of an arch. This is very true; but there is another force which produces the same effect, and which increases nearly in the proportion that those thrusts increase, because it arises from them. This is the friction of the stones on each other. In dry freestone this friction considerably exceeds one half of the mutual pressure. The reflecting reader will see that this produces the same effect, in the case under consideration, that cohesion would do; for while the arch is in the act of failing, the mutual pressure of the arch-stones is acting with full force, and thus produces a friction more than adequate to all the effects we have been speaking of.

Process of the breaking of an arch.

30. When these circumstances are considered, we imagine that it will appear that an arch, when exposed to a great overload on the crown (or indeed on any part), divides of itself into a number of parts, each of which contains as many arch-stones as can be pierced (so to speak) by one straight line, and that it may then be considered as nearly in the same situation with a polygonal arch of long stones abutting on each other like so many beams in a Norman roof, but without their braces and ties. It tends to break at all those angles; and it is not sufficiently resisted there, because the materials with which the flanks are filled up have so little cohesion, that the angle feels no load except what is immediately above it; whereas it should be immediately loaded with all the weight which is diffused over the adjoining side of the polygon. This will be the case, even though the curvilinear arch be perfectly equilibrated. We recollect some circumstances in the failure of a considerable arch, which may be worth mentioning. It had been built of an exceedingly soft and friable stone, and the arch-stones were too short. About a fortnight before it fell, chips were observed to be dropping off from the joints of the arch-stones, about ten feet on each side of the middle, and also from another place on one side of the arch, about twenty feet from its middle. The masons in the neighbourhood prognosticated its speedy downfall, and said that it would separate in those places where the chips were breaking off. At length it fell; but it first split in the middle, and about fifteen or sixteen feet on each side, and also at the very springing of the arch. Immediately before the fall a shivering or crackling noise was heard, and a great many chips dropped down from the middle, between the two places from whence they had dropped a fortnight before. The joints opened above at those new places above two inches, and in the middle of the arch the joints opened below, and in about five minutes after this the whole came down. Even this movement was plainly distinguishable into two parts. The crown sunk a little, and the haunches rose very sensibly, and in this state it hung for about half a minute. The arch-stones of the crown were hanging by their upper corners: when these splintered off, the whole fell down.

We apprehend that the procedure of nature was somewhat in this manner. Straight lines can be drawn within the arch-stones from A (Plate LIII. fig. 8) to B and D, and from these points to C and E. Each of the portions ED, DA, AB, BC, resist as if they were of one stone, composing a polygonal vault EDABC. When this is overloaded at A, A can descend in no other way than by pushing the angles B and D outwards, causing the portions BC, DE, to turn round C and E. This motion must raise the points B and D, and cause the arch-stones to press on each other at their *inner* joints *b* and *d*. This produced the copious splintering at those joints immediately preceding the total downfall. The splintering which happened a fortnight before arose from this circumstance, that the lines AB and AD, along which the pressure of the overload was propagated, were tangents to the soffit of the arch in the points F, H, and G, and therefore the strain lay all on those corners of the arch-stones, and splintered a little from off them till the whole took a firmer bed. The subsequent phenomena are evident consequences of this distribution and modification of pressure, and can hardly be explained in any other way, at least not on the theoretical principles already set forth; for in this bridge the loads at B and D were very considerably greater than what the equilibrium required; and we think that the first observed splintering at H, F, and G, was most instructive, showing that there was an extraordinary pressure at the inner joints in those places, which cannot be explained by the usual theory.

Not satisfied with this single observation after this way of explaining it occurred to us, and not being able to find any similar fact on record, the writer of this article got some small models of arches executed in chalk, and subjected them to many trials, in hopes of collecting some general laws of the internal workings of arches which finally produce their downfall. He had the pleasure of observing the above-mentioned circumstances take place very regularly and uniformly when he overloaded the models at A. The arch always broke at some place B considerably beyond another point F, where the first chipping had been observed. This is a method of trial that deserves the attention both of the speculatist and the practitioner.

If these reflections are any thing like a just account of the procedure of nature in the failure of an arch, it is evident that the ingenious mathematical theory of equilibrated arches is of little value to the engineer. We ventured to say as much already, and we rested a good deal on the authority of Sir Christopher Wren. He was a good mathematician, and delighted in the application of this science to the arts. He was a celebrated architect, and his reports on the various works committed to his charge show that he was in the continued habit of making this application. Several specimens remain of his own methods of applying them. The roof of the theatre of Oxford, the roof of the cupola of St Paul's, and in particular the mould on which he turned the inner dome of that cathedral, are proofs of his having studied this theory most attentively. He flourished at the very time that it occupied the attention of the greatest mechanicians of Europe; but there is nothing to be found among his papers which shows that he had paid much regard to it. On the contrary, when he has occasion to deliver his opinion for the instruction of others, and to explain to the dean and chapter of Westminster his operations in repairing that collegiate church, this great architect considers an arch just as a sensible and sagacious mason would do, and very much in the way that we have just now been treating it. (See *Account of the Family of Wren*, p. 356.) Supported therefore by such authority, we would recommend this way of considering an arch to the study of the mathematician; and we would desire the experienced mason to think of the most efficacious methods for resisting this tendency of arches to rise in the flanks. Unfortunately there seems to be no precise principle to point out the place where this tendency is most remarkable.

31. We are therefore highly pleased with the ingenious

contrivance of Mr Mylne, the architect of Blackfriars Bridge in London, by which he determines this point with precision, by making it impossible for the overloaded arch to spring in any other place. Having thus confined the failure to a particular spot, he with equal art opposes a resistance which he believes to be sufficient; and the present condition of that noble bridge, which does not in any place show the smallest change of shape, proves that he was not mistaken. Looking on this work as the first, or at least the second, specimen of masonic ingenuity that is to be seen in the world, we imagine that our readers will be pleased with a particular account of its most remarkable circumstances.

The span *k a* (fig. 1) of the middle arch is 100 feet, and its height OV is 40, and the thickness KV of the crown is six feet seven inches. Its form is nearly elliptical; the part AVZ being an arch of a circle whose centre is C, and radius 56 feet, and the two lateral portions A *k* B and Z *a* E being arches described with a radius of 35 feet nearly. The thickness of the pier at *a b* is 19 feet. The thickness of the arch increases from the crown V to Y, where it is eight or nine feet. All the arch-stones have their joints directed to the centres of their curvature. The joints are all joggled, having a cubic foot of hard stone let half-way into each. By this contrivance the joints cannot slide, nor can any weight laid on the crown ever break the arch in that part if the piers do not yield; for a straight line from the middle of KV to the middle of the joint YI is contained within the solid masonry, and does not even come near the inner joints of the arch-stones; therefore the whole resists like one stone, and can be only broken by crushing it. The joint at Z is very nearly perpendicular to a line ZF drawn to the outer edge of the foundation of the pier. By this it was intended to take off all tendency of the pressure on the joint *d* Z to overset the pier; for if we suppose, according to the theory of equilibration, that this pressure is necessarily exerted perpendicularly to the joint, its direction passes through the fulcrum at F, round which it is thought that the pier must turn in the act of oversetting. This precaution was adopted in order to make the arch quite independent of the adjoining arches; so that although any of them should fall, this arch should run no risk.

Still farther to secure the independence of the arch, the following construction was practised to unite it into one mass, which should rise all together. All below the line *a b* is built of large blocks of Portland stone, dovetailed with sound oak. Four places in each course are interrupted by equal blocks of a hard stone called *Kentish rag*, sunk half-way in each course. These act as joggles, breaking the courses, and preventing them from sliding laterally.

The portion *a* Y of the arch is joggled like the upper part. The interior part is filled up with large blocks of Kentish rag, forming a kind of coursed rubble-work, the courses tending to the centres of the arch. The under corner of each arch-stone projects over the one below it. By this form it takes fast hold of the rubble-work behind it. Above this rubble there is constructed the inverted arch I *e* G of Portland stone.[1] This arch shares the pressure of the two adjoining arches, along with the arch-stones in Y *a* and in G *b*. Thus all tend together to compress and keep down the rubble-work in the heart of this part of the pier. This is a very useful precaution; for it often happens, that when the centres of the arches are struck before the piers are built up to their intended heights, the thrust of the arches squeezes the rubble-work horizontally, after the mortar has set, but before it has dried and acquired its utmost hardness. Its bond is broken by this motion, and it is squeezed up, and never acquires its former firmness. This is effectually prevented by the pressure exerted by the back of the inverted arch.

Above this counter-arch is another mass of coursed rubble, and all is covered by a horizontal course of large blocks of Portland stone, abutting against the back of the arch-stone ZI and its corresponding one in the adjoining arch. This course connects the feet of the two arches, preserves the rubble-work from too great compression, and protects it from soaking water. This last circumstance is important; for if the water which falls on the road-way is not carried off in pipes, it soaks through the gravel or other rubbish, rests on the mortar, and keeps it continually wet and soft. It cannot escape through the joints of good masonry, and therefore fills up this part like a funnel.

Supposing the adjoining arch fallen, and all tumbled off that is not withheld by its situation, there will still remain in the pier a mass of about 3500 tons. The weight of the portion VY is about 2000 tons. The directions of the thrusts VY and YF are such, that it would require a load of 4500 tons on VY to overturn the pier round F. This exceeds VY by 2500 tons—a weight incomparably greater than any that can ever be laid on it.

Such is the ingenious construction of Mr Mylne. It evidently proceeds on the principles recommended above—principles which had occurred to his experience and sagacious mind during the course of his extensive practice. We have seen attempts by other engineers to withstand the horizontal thrusts of the arch by means of counter-arches inserted in the same manner as here, but extending much farther over the main arch; but they did not appear to be well calculated for producing this effect. A counter-arch springing from any point between Y and V has no tendency to hinder that point from rising by the sinking of the crown; and such a counter-arch will not resist the precisely horizontal thrust so well as the straight course of Mr Mylne.

Origin of the Gothic arches.

32. The great incorporation of architects who built the cathedrals of Europe departed entirely from the styles of ancient Greece and Rome, and introduced another, in which arcades made the principal part. Not finding in every place quarries from which blocks could be raised in abundance of sufficient size for forming the far-projecting cornices of the Greek orders, they relinquished those proportions, and adopted a style of ornament which required no such projections; and having substituted arches for the horizontal architrave or lintel, they were now able to erect buildings of vast extent with spacious openings, and all this with very small pieces of stone. The form which had been adopted for a Christian temple occasioned many intersections of vaultings, and multiplied the arches exceedingly. Constant practice gave opportunities of giving every possible variety of these intersections, and taught the art of balancing arch against arch in every variety of situation. An art so multifarious, and so much out of the road of ordinary thought, could not but become an object of fond study to the architects most eminent for ingenuity and invention. Becoming thus the dupes of

[1] We know from good authority that the counter-arch here spoken of, although originally intended, was never executed, because it was not thought necessary. The notion was, however, excellent, and it has, we believe, been actually executed in the Strand Bridge. We rather think the joggling was also abandoned, and, as far as we can judge, was not likely to be of any use. (R.)

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their own ingenuity, they were fond of displaying it even when not necessary. At last arches became their principal ornament, and a wall or ceiling was not thought dressed out as it should be till filled full of mock arches, crossing and abutting on each other in every direction. In this process in their ceilings they found that the projecting mouldings, which we now call the Gothic tracery, formed the chief supports of the roofs. The plane surfaces included between those ribs were commonly vaulted with very small stones, seldom exceeding six or eight inches in thickness. This tracery, therefore, was not a random ornament. Every rib had a position and direction that was not only proper, but even necessary. Habituated to this scientific arrangement of the mouldings, they did not deviate from it when they ornamented a smooth surface with mock arches; and in none of the highly ornamented *ancient* buildings will we find any false positions.

33. This is by no means the case in many of the modern imitations of Gothic architecture, even by our best architects. Ignorant of the directing principle, or not attending to it, in their stucco-work they please the unskilled eye with pretty radiated figures; but in these we frequently see such abutments of mouldings as would infallibly break the arches, if these mouldings were really performing their ancient office, and supporting a vaulting of considerable extent. Nay, this began even before the Gothic style was finally abandoned. Several instances are to be found in the highly enriched vaultings of New College and Christ Church in Oxford, in St George's Chapel at Windsor, and Henry VII.'s Chapel in Westminster.

We call the middle ages rude and barbarous; but there was surely much knowledge in those who could execute such magnificent and difficult works. The working drafts which were necessary for such varieties of oblique intersections must have required considerable skill, and would at present occupy many very expensive volumes of *Masons' Jewels*, *Carpenters' Manuals*, and the like. All this knowledge was kept a profound secret by the corporation, and on its breaking up we had all to learn again.

34. There is no appearance, however, that those architects had studied the theory of equilibrated arches. They had adopted an arch which was very strong, and permitted considerable irregularities of pressure—we mean the pointed arch. The very deep mouldings with which it was ornamented made the arch-stones very long in proportion to the span of the arch. But they had studied the mutual thrust of arches on each other with great care; and they contrived to make every invention for this purpose become an ornament, so that the eye *required* it as a necessary part of the building. Thus we frequently see small buildings having buttresses at the sides. These are necessary in a large vaulted building, for withstanding the outward thrust of the vaulting; but they are useless when we have a flat ceiling within. Pinnacles on the heads of the buttresses are now considered as ornaments, but originally they were put there to increase the weight of the buttress: even the great tower in the centre of a cathedral, which now constitutes its greatest ornament, is a load almost indispensably necessary, for enabling the four principal columns to withstand the combined thrust of the aisles, of the nave, and transepts. In short, the more closely we examine the ornaments of this architecture, the more shall we perceive that they are essential parts, or derived from them by imitation; and the more we consider the whole style of it, the more clearly do we see that it is all deduced from the relish for arcades, indulged in the extreme, and pushed to the limit of possibility of execution.

35. There is another species of arch which must not be overlooked, namely, the Dome or Cupola, with all its varieties, which include even the pyramidal steeple or spire.

It is evident that the erection of a dome is also a scientific art, proceeding on the principles of equilibration, and that these principles admit and require the same or similar modifications, in consequence of the cohesion and friction of the materials. At first sight, too, a dome appears a more difficult piece of work than a plain arch; but when we observe potters' kilns, and glasshouse domes, and cones of vast extent, erected by ordinary bricklayers, and with materials vastly inferior in size to what can be employed in common arches of equal extent, we must conclude that the circumstance of curvature in the horizontal direction, or the abutment of a circular base, gives some assistance to the artist. Of this we have complete demonstration in the case of the cone. We know that a vaulting in the form of a pent roof could not be executed to any considerable extent, and would be extremely hazardous, even in the smallest dimensions; while a cone of the greatest magnitude can be raised with very small stones, provided only that we prevent the bottom from flying out, by a hoop, or any similar contrivance.

36. When we think a little of the matter, we see plainly, that if the horizontal section be perfectly round, and the joints be all directed to the axis, they all equally endeavour to slide inwards, while no reason can be offered why any individual stone should prevail. They are all wedges, and operate only as wedges. When we consider any single course, therefore, we see that it cannot fall in, even though it may be part of a curve which cannot stand as a common arch; nay, we see that a dome may be constructed having the convexity of the curve, by the revolution of which it is formed, turned towards the axis, so that the outline is concave. We shall afterwards find that this is a stronger dome by far than if the convexity were outwards, as in a common arch. We see also that a cone may be loaded on the top with the greatest weight, without the smallest danger of forcing it down, so long as the bottom course is firmly kept from bursting outwards. The stone lanthorn on the top of St Paul's cathedral in London weighs several hundred tons, and is carried by a brick cone of 18 inches thick, with perfect safety, as long as the bottom course is prevented from bursting outwards. The reason is evident: The pressure on the top is propagated along the cone in the direction of the slant side; and, so far from having any tendency to break it in any part, it tends rather to prevent its being broken by any irregular pressure from foreign causes.

37. For the same reasons the octagonal pyramids, which form the spires of Gothic architecture, are abundantly firm, although very thin. The sides of the spire of Salisbury cathedral are not eight inches thick after the octagon is fully formed. It is proper, however, to direct the joints to the axis of the pyramid, and to make the coursing joints perpendicular to the slant side, because the projecting mouldings which run along the angles are the abutments on which the whole panel depends. A considerable art is necessary for supporting those panels or sides of the octagon which spring from the angles of the square tower. This is done by beginning a very narrow pointed arch on the square tower at a great distance below the top; so that the legs of the arch being very long, a straight line may be drawn from the top of the keystone of the arch through the whole arch-stones of the legs. By this disposition the thrusts arising from the weight of these four panels are made to meet on the massive masonry in the middle of the sides of the tower, at a great

distance below the springing of the spire. This part, being loaded with the great mass of perpendicular wall, is fully able to withstand the horizontal thrust from the legs of those arches. In many spires these thrusts are still farther resisted by iron bars which cross the tower, and are hooked into pieces of brass firmly bedded in the masonry of the sides.

38. There is much nice balancing of this kind to be observed in the highly ornamented open spires; such as those of Brussels, Mecklin, Antwerp, &c. We have not many of this sort in Britain. In those of great magnitude, the judicious eye will discover, that parts, which a common spectator would consider as mere ornaments, are necessary for completing the balance of the whole. Tall pinnacles, nay even pillars carrying entablatures and pinnacles, are to be seen standing on the middle of the slender leg of an arch. On examination we find that this is necessary, to prevent the arch from springing upwards in that place by the pressure at the crown. The steeple of the cathedral of Mecklin was the most elaborate piece of architecture in this taste in the world, and was really a wonder; but it was not calculated to withstand a bombardment, which destroyed it in 1578.

Such frequent examples of irregular and whimsical buildings of this kind show that great liberties may be taken with the principle of equilibration without risk, if we take care to secure the base from being thrust outwards. This may always be done by hoops, which can be concealed in the masonry; whereas in common arches these ties would be visible, and would offend the eye.

39. It is now time to attend to the principle of equilibrium as it operates in a simple circular dome, and to determine the thickness of the vaulting when the curve is given, or the curve when the thickness is given. Therefore, let B b A (Plate LIII. fig. 2) be the curve which produces the dome by revolving round the vertical axis AD. We shall suppose this curve to be drawn through the middle of all the arch-stones, and that the coursing or horizontal joints are everywhere perpendicular to the curve. We shall suppose (as is always the case) that the thickness KL, HI, &c. of the arch-stones is very small in comparison with the dimensions of the arch. If we consider any portion HA h of the dome, it is plain that it presses on the course, of which HL is an arch-stone, in a direction b C perpendicular to the joint HI, or in the direction of the next superior element βb of the curve. As we proceed downwards, course after course, we see plainly that this direction must change, because the weight of each course is superadded to that of the portion above it, to complete the pressure on the course below. Through B draw the vertical line BCG, meeting βb, produced in C. We may take b C to express the pressure of all that is above it, propagated in this direction to the joint KL. We may also suppose the weight of the course HL united in b, and acting on the vertical. Let it be represented by b F. If we form the parallelogram b FGC, the diagonal b G will represent the direction and intensity of the whole pressure on the joint KL. Thus it appears that this pressure is continually changing its direction, and that the line, which will always coincide with it, must be a curve concave downward. If this be precisely the curve of the dome, it will be an equilibrated vaulting; but so far from being the strongest form, it is the weakest, and it is the limit to an infinity of others, which are all stronger than it. This will appear evident, if we suppose that b G does not coincide with the curve A b B, but passes without it. As we suppose the arch-stones to be exceedingly thin from inside to outside, it is plain that this dome cannot stand, and that the weight of the upper part will press it down, and spring the vaulting outwards at the joint KL. But let us suppose, on the other hand, that b G falls within the curvilinear element b B. This evidently tends to push the arch-stone inward towards the axis, and would cause it to slide in, since the joints are supposed perfectly smooth and slipping. But since this takes place equally in every stone of this course, they must all abut on each other in the vertical joints, squeezing them firmly together. Therefore, resolving the thrust b G into two, one of which is perpendicular to the joint KL, and the other parallel to it, we see that this last thrust is withstood by the vertical joints all around, and there remains only the thrust in the direction of the curve. Such a dome must therefore be firmer than an equilibrated dome, and cannot be so easily broken by overloading the upper part. When the curve is concave upwards, as in the lower part of the figure, the line b C always falls below b B, and the point C below B. When the curve is concave downwards, as in the upper part of the figure, b' C′ passes above, or without b B. The curvature may be so abrupt, that even b' G′ shall pass without b' B′, and the point G′ is above B′. It is also evident that the force which thus binds the stones of a horizontal course together, by pushing them towards the axis, will be greater in flat domes than in those that are more convex; that it will be still greater in a cone, and greater still in a curve whose convexity is turned inwards; for in this last case the line b G will deviate most remarkably from the curve. Such a dome will stand (having polished joints) if the curve springs from the base with any elevation, however small; nay, since the friction of two pieces of stone is not less than half of their mutual pressure, such a dome will stand although the tangent to the curve at the bottom should be horizontal, provided that the horizontal thrust be double the weight of the dome, which may easily be the case if it do not rise high.

Stability of a dome depends on principles different from that of a common arch.

40. Thus we see that the stability of a dome depends on very different principles from that of a common arch, and is in general much greater. It differs also in another very important circumstance, viz. that it may be open in the middle; for the uppermost course, by tending equally in every part to slide in toward the axis, presses all together in the vertical joints, and acts on the next course like the keystone of a common arch. Therefore an arch of equilibration, which is the weakest of all, may be open in the middle, and carry at top another building, such as a lanthorn, if its weight do not exceed that of the circular segment of the dome that is omitted. A greater load than this would indeed break the dome, by causing it to spring up in some of the lower courses; but this load may be increased if the curve is flatter than the curve of equilibration: and any load whatever, which will not crush the stones to powder, may be set on a truncate cone, or on a dome formed by a curve that is convex toward the axis; provided always that the foundation be effectually prevented from flying out, either by a hoop, or by a sufficient mass of solid pier on which it is set.

41. We have mentioned the many failures which happened to the dome of St Sophia in Constantinople. We imagine that the thrust of the great dome, bending the eastern arch outwards as soon as the pier began to yield, destroyed the half-dome which was leaning on it, and thus almost in an instant took away the eastern abutment. We think that this might have been prevented without any change in the injudicious plan, if the dome had been hooped with iron, as was practised by Michael Angelo in the vastly more ponderous dome of St Peter's at Rome, and by Sir Christopher Wren in the cone and the inner dome of St Paul's at London. The weight of the latter considerably exceeds 3000 tons, and they occasion a horizontal thrust which is nearly half this quantity, the elevation of the cone being about 60°. This being distributed

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round the circumference, occasions a strain on the hoop $= \frac{7}{2 \times 22}$ of the thrust, or nearly 238 tons. A square inch of the worst iron, if well forged, will carry 24 tons with perfect safety; therefore a hoop of 7 inches broad and $1\frac{1}{2}$ inch thick will completely secure this circle from bursting outwards. It is, however, much more completely secured; for, besides a hoop at the base of very nearly these dimensions, there are hoops in different courses of the cone, which bind it into one mass, and cause it to press on the piers in a direction exactly vertical. The only thrusts which the piers sustain are those from the arches of the body of the church and the transepts. These are most judiciously directed to the entering angles of the building, and are there resisted with insuperable force by the whole lengths of the walls, and by four solid masses of masonry in the corners. Whoever considers with attention and judgment the plan of this cathedral, will see that the thrusts of these arches, and of the dome, are incomparably better balanced than in St Peter's church at Rome. But to return from this sort of digression.

Theory of the curves proper for domes.

42. We have seen that if bG, the thrust compounded of the thrust bC, exerted by all the courses above HILK, and of the force bF, or the weight of that course, be everywhere coincident with bB, the element of the curve, we shall have an equilibrated dome: if it falls within it, we have a dome which will bear a greater load; and if it falls without it, the dome will break at the joint. We must endeavour to get analytical expressions of these conditions. Therefore draw the ordinates $b\delta b''$, BDB″, CdC″. Let the tangents at b and b'' meet the axis in M, and make MO, MP, each equal to bc, and complete the parallelogram MONP, and draw OQ perpendicular to the axis, and produce bF, cutting the ordinates in E and e.[1] It is plain that MN is to MO as the weight of the arch HAb to the thrust bC which it exerts on the joint KL (this thrust being propagated through the course HILK); and that MQ, or its equal be, or δd, may represent the weight of the half HA.

Let AD be called x, and DB be called y. Then $be = dx$, and eC $= dy$ (because bC is in the direction of the element βb). It is also plain that if we make dy constant, BC is the second fluxion of x, or BC $= d^2x$, and be and bE may be considered as equal, and taken indiscriminately for dx. We have also bC $= \sqrt{dx^2 + dy^2}$. Let h be the depth or thickness HI of the arch-stones. Then $h\sqrt{dx^2 + dy^2}$ will represent the trapezium HL; and since the circumference of each course increases in the proportion of the radius y, $hy\sqrt{dx^2 + dy^2}$ will express the whole course. If $\int$ be taken to represent the sum or aggregate of the quantities annexed to it, the formula will be analogous to the fluent of a fluxion, and $\int hy\sqrt{dx^2 + dy^2}$ will represent the whole mass, and also the weight of the vaulting, down to the joint HI. Therefore we have this proportion, $\int hy\sqrt{dx^2 + dy^2} : hy\sqrt{dx^2 + dy^2} :: be : b$F, $= be$: CG, $= \delta d$: CG, $= dx$: CG. Therefore CG $= \frac{hydx\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}}$.

If the curvature of the dome be precisely such as puts it in equilibrium, but without any mutual pressure in the vertical joints, this value of CG must be equal to CB or to d^2x, the point G coinciding with B. This condition will be expressed by the equation $\frac{hydx\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}} = d^2x$, or, more conveniently, by $\frac{hy\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}} = \frac{d^2x}{dx}$. But this form gives only a tottering equilibrium, independent of the friction of the joints and the cohesion of the cement. An equilibrium, accompanied by some firm stability, produced by the mutual pressure of the vertical joints, may be expressed by the formula $\frac{hy\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}} > \frac{d^2x}{dx}$, or by $\frac{hy\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}} = \frac{d^2x}{dx} + \frac{dt}{t}$, where t is some variable positive quantity, which increases when x increases. This last equation will also express the equilibrated dome, if t be a constant quantity, because in this case $\frac{dt}{t}$ is $= 0$.

Since a firm stability requires that $\frac{hydx\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}}$ shall be greater than d^2x, and CG must be greater than CB; hence we learn that figures of too great curvature, whose sides descend too rapidly, are improper. Also, since stability requires that we have $\frac{hydx\sqrt{dx^2 + dy^2}}{d^2x}$ greater than $\int hy\sqrt{dx^2 + dy^2}$, we learn that the upper part of the dome must not be made very heavy. This, by diminishing the proportion of bF to bC, diminishes the angle CbG, and may set the point G above B, which will infallibly spring the dome in that place. We see here also, that the algebraic analysis expresses that peculiarity of dome-vaulting, viz. that the weight of the upper part may even be suppressed.

The fluent of the equation $\frac{hy\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}} = \frac{d^2x}{dx} + \frac{dt}{t}$ is most easily found: it is $\mathrm{L}\int hy\sqrt{dx^2 + dy^2} = \mathrm{L}dx + \mathrm{L}t$, where L is the hyperbolic logarithm of the quantity annexed to it. If we consider dy as constant, and correct the fluent so as to make it nothing at the vertex, it may be expressed thus, $\mathrm{L}\int hy\sqrt{dx^2 + dy^2} - \mathrm{L}a = \mathrm{L}dx - \mathrm{L}dy + \mathrm{L}t$. This gives us $\mathrm{L}\frac{\int hy\sqrt{dx^2 + dy^2}}{a} = \mathrm{L}\frac{dx}{dy}t$, and therefore $\frac{\int hy\sqrt{dx^2 + dy^2}}{a} = t\frac{dx}{dy}$.

This last equation will easily give us the depth of vaulting, or thickness h of the arch, when the curve is given. For its fluxion is $\frac{hy\sqrt{dx^2 + dy^2}}{a} = \frac{dtdx + td^2x}{dy}$, and $h = \frac{adtdx + atd^2x}{ydy\sqrt{dx^2 + dy^2}}$, which is all expressed in known quantities; for we may put in place of t any power or function of x or of y, and thus convert the expression into another, which will be applicable to all sorts of curves.

Instead of the second member $\frac{d^2x}{dx} + \frac{dt}{t}$, we might employ $\frac{pd^2x}{dx}$, where p is some number greater than unity. This will evidently give a dome having stability, because the original formula $\frac{hydx\sqrt{dx^2 + dy^2}}{\int hy\sqrt{dx^2 + dy^2}}$ will then be greater than d^2x. This will give $h = \frac{pax^{p-1}d^2x}{ydy^p\sqrt{dx^2 + dy^2}}$. Each of these forms has its advantages when applied to particular cases. Each of them also gives $h = \frac{ad^2x}{ydy\sqrt{dx^2 + dy^2}}$ when the curvature is such as is in precise equilibrium.

[1] The letters e and d are wanting in the plate; e ought to be at the intersection of bE and Cc'', and d at that of AD and Cc''.

And, lastly, if h be constant, that is, if the vaulting be of uniform thickness, we obtain the form of the curve, because then the relation of d^2x to dx and to dy is given.

The chief use of this analysis is to discover what curves are improper for domes, or what portions of given curves may be employed with safety. Domes are generally built for ornament, and we see that there is great room for indulging our fancy in the choice. All curves which are concave outwards will give domes of great firmness: they are also beautiful. The Gothic dome, whose outline is an undulated curve, may be made abundantly firm, especially if the upper part be convex and the lower concave outwards.

The chief difficulty in the case of this analysis arises from the necessity of expressing the weight of the incumbent part, or $\int hy\sqrt{dx^2+dy^2}$. This requires the measurement of the conoidal surface, which, in most cases, can be had only by approximation by means of infinite series. We cannot expect that the generality of practical builders are familiar with this branch of mathematics, and therefore will not engage in it here; but content ourselves with giving such instances as can be understood by such as have that moderate mathematical knowledge which every man should possess who takes the name of engineer.

The surface of any circular portion of a sphere is very easily had, being equal to the circle described with a radius equal to the chord of half the arch. This radius is evidently $=\sqrt{dx^2+dy^2}$.

In order to discover what portion of a hemisphere may be employed (for it is evident that we cannot employ the whole) when the thickness of the vaulting is uniform, we may recur to the equation or formula $\frac{hydx\sqrt{dx^2+dy^2}}{dx^2}$ $=\int hy\sqrt{dx^2+dy^2}$. Let a be the radius of the hemisphere. We have $dx=\frac{aydy}{\sqrt{a^2-y^2}}$, and $d^2x=\frac{a^2dy^2}{(a^2-y^2)^{\frac{3}{2}}}$. Substituting these values in the formula, we obtain the equation $y^2\sqrt{a^2-y^2}=\int\frac{a^2ydy}{\sqrt{a^2-y^2}}$. We easily obtain the fluent of the second member $=a^3-a^2\sqrt{a^2-y^2}$, and $y=a\sqrt{-\frac{1}{2}+\sqrt{\frac{5}{4}}}$. Therefore, if the radius of the sphere be 1, the half breadth of the dome must not exceed $\sqrt{-\frac{1}{2}+\sqrt{\frac{5}{4}}}$, or 0·786, and the height will be ·618. The arch from the vertex is about 51° 49′. Much more of the hemisphere cannot stand, even though aided by the cement, and by the friction of the coursing joints. This last circumstance, by giving connection to the upper parts, causes the whole to press more vertically on the course below, and thus diminishes the outward thrust; but it at the same time diminishes the mutual abutment of the vertical joints, which is a great cause of firmness in the vaulting. A Gothic dome, of which the upper part is a portion of a sphere not exceeding 45° from the vertex, and the lower part is concave outwards, will be very strong, and not ungraceful.

43. But the public taste has long rejected this form, and seems rather to select more elevated domes than this portion of a sphere, because a dome, when seen from a small distance, always appears flatter than it really is. The dome of St Peter's is nearly an ellipsoid externally, of which the longer axis is perpendicular to the horizon. It is very ingeniously constructed. It springs from the base perpendicularly, and is very thick in this part. After rising about 50 feet, the vaulting separates into two thin vaultings, which gradually separate from each other. These two shells are connected together by thin partitions, which are very artificially dovetailed in both, and thus form a covering which is extremely stiff, while it is very light. Its great stiffness was necessary for enabling the crown of the dome to carry the elegant stone lanthorn with safety. It is a wonderful performance and has not its equal in the world; but it is an enormous load in comparison with the dome of St Paul's, and this even independent of the difference of size. If they were of equal dimensions, it would be at least five times as heavy, and is not so firm by its gravity; but as it is connected in every part by iron bars (lodged in the solid masonry, and well secured from the weather by having lead melted all around them), it bids fair to last for ages if the foundations do not fail.

If a circle be described round a centre, placed anywhere in the transverse axis AC (Plate LII. fig. 11) of an ellipse, so as to touch the ellipse in the extremities B, b of an ordinate, it will touch it internally, and the circular arch B a b will be wholly within the elliptical arch B$a$$b$. Therefore, if an elliptical and a spherical vaulting spring from the same base, at the same angle with the horizon, the spherical vaulting will be within the elliptical, will be flatter and lighter, and therefore the weight of the next course below will bear a greater proportion to the thrust in the direction of the curve; therefore the spherical vaulting will have more stability. On the contrary, and for similar reasons, an oblate elliptical vaulting is preferable to a spherical vaulting springing with the same inclination to the horizon. (Fig. 13.)

Dimensions of the best form of a dome.

44. Persuaded that what has been said on the subject convinces the reader that a vaulting perfectly equilibrated throughout is by no means the best form, provided that the base is secured from separating, we think it unnecessary to give the investigation of that form, which has a considerable intricacy, and shall content ourselves with merely giving its dimensions. The thickness is supposed uniform. The numbers in the first column of the table express the portion of the axis counted from the vertex, and those of the second column are the lengths of the ordinates.

AD	DB	AD	DB	AD	DB
0,4	100	610,4	1080	2990	1560
3,4	200	744	1140	3442	1600
11,4	300	904	1200	3972	1640
26,6	400	1100	1260	4432	1670
52,4	500	1336	1320	4952	1700
91,4	600	1522	1360	5336	1720
146,8	700	1738	1400	5756	1740
223,4	800	1984	1440	6214	1760
326,6	900	2270	1480	6714	1780
465,4	1000	2602	1520	7260	1800

The curve delineated in fig. 15 is formed according to these dimensions, and appears destitute of gracefulness, because its curvature changes abruptly at a little distance from the vertex, so that it has some appearance of being made up of different curves pieced together. But if the middle be occupied by a lanthorn of equal or of smaller weight, this defect will cease, and the whole will be elegant, nearly resembling the exterior dome of St Paul's in London.

Advantages of dome-vaulting.

45. It is not a small advantage of dome-vaulting, that it is lighter than any that can cover the same area. If, moreover, it be spherical, it will admit considerable varieties of figure by combining different spheres. Thus, a dome may begin from its base as a portion of a large hemisphere, and may be broken off at any horizontal

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course, and then a similar or a greater portion of a smaller sphere may spring from this course as a base. It also bears being intersected by cylindrical vaultings in every direction, and the intersections are exact circles, and always have a pleasing effect. It also springs most gracefully from the heads of small piers, or from the corners of rooms of any polygonal shape; and the arches formed by its intersections with the walls are always circular and graceful, forming very handsome spandrels in every position. For these reasons Sir Christopher Wren employed it in all his vaultings, and he has exhibited many beautiful varieties in the transepts and the aisles of St Paul's, which are highly worthy of the observation of architects. Nothing can be more graceful than the vaultings at the ends of the north and south transepts, especially as furnished off in the fine inside view published by Gwynn and Wale.

Effects of cement and friction in dome-vaulting.

46. The connection of the parts arising from cement and from friction has a great effect on dome-vaulting. In the same way as in common arches and cylindrical vaulting, it enables an overload on one place to break the dome in a distant place. But the resistance to this effect is much greater in dome-vaulting, because it operates all round the overloaded part. Hence it happens that domes are much less shattered by partial violence, such as the falling of a bomb or the like. Large holes may be broken in them without much affecting the rest; but, on the other hand, it greatly diminishes the strength which should be derived from the mutual pressure in the vertical joints. Friction prevents the sliding in of the arch-stones, which produces this mutual pressure in the vertical joints, except in the very highest courses, and even there it greatly diminishes it. These causes make a great change in the form which gives the greatest strength; and as their laws of action are as yet but very imperfectly understood, it is perhaps impossible, in the present state of our knowledge, to determine this form with tolerable precision. We see plainly, however, that it allows a greater deviation from the best form than the other kind of vaulting, and domes may be made to rise perpendicular to the horizon at the base, although of no great thickness; a thing which must not be attempted in a plain arch. The immense addition of strength which may be derived from hooping largely compensates for all defects; and there are hardly any bounds to the extent to which a very thin dome-vaulting may be carried when it is hooped or framed in the direction of the horizontal courses. The roof of the Halle du Bled at Paris is but a foot thick, and its diameter is more than 200, yet it appears to have abundant strength. It is, on the whole, a noble specimen of architecture.

The iron bridge at Sunderland described.

47. We must not conclude this article without taking notice of that magnificent and elegant arch erected in cast iron at Wearmouth, near Sunderland, in the county of Durham. The inventor and architect was Rowland Burdon, Esq.

This arch (of which a view is given at the article Bridge) is a segment of a circle whose diameter is about 444 feet. The span or chord of the arch is 236 feet, and its versed sine or spring is 34 feet. It springs at the elevation of 60 feet from the surface of the river at low water, so that vessels of 200 or perhaps 300 tons burden may pass under it in the middle of the stream, and even 50 feet on each side of it.

The sweep of the arch consists of a series of frames of cast iron, which abut on each other, in the same manner as the voussoirs of a stone arch. One of these frames or blocks (as we shall call them in future) is represented in Plate LIII. fig. 3, as seen in front. It is cast in one piece, and consists of three pieces or arms BC, BC, BC, the middle one of which is two feet long, the upper being somewhat more, and the lower somewhat less, because their extremities are bounded by the radius drawn from the centre of the arch. These arms are four inches square, and are connected by other pieces KL, of such length that the whole length of the block is five feet in the direction of the radius. Each arm has a flat groove on each side, which is expressed by the darker shading, three inches broad and three fourths of an inch deep. A section of this block, through the middle of KL, is represented by the light-shaded part BBB, in which the grooves are more distinctly perceived. These grooves are intended for receiving flat bars of malleable iron, which are employed for connecting the different blocks with each other. Fig. 4 represents two blocks united in this manner. For this purpose each arm has two square bolt-holes. The ends of the arms being nicely trimmed off, so that the three ends abut equally close on the ends of the next block; and the bars of hammered iron being also nicely fitted to their grooves, so as to fill them completely, and have their bolt-holes exactly corresponding to those in the blocks; they are put together in such a manner that the joints or meetings of the malleable bars may fall on the middle between the bolt-holes in the arms. Flat-headed bolts of wrought iron are then put through, and keys or forelocks are driven through the bolt-tails, and thus all is firmly wedged together, binding each arm between two bars of wrought iron. These bars are of such length as to connect several blocks.

In this manner a series of about 125 blocks are joined together, so as to form the precise curve that is intended. This series may be called a rib, and it stands in a vertical plane. The arch consists of six of these ribs, distant from each other five feet. These ribs are connected together so as to form an arch of 32 feet in breadth, in the following manner.

Fig. 5 represents one of the bridles or cross pieces which connect the different ribs, as it appears when viewed from below. It is a hollow pipe of cast iron four inches in diameter, and has at each end two projecting shoulders, pierced with a bolt-hole near their extremities, so that the distance between the bolt-holes in the shoulders of one end is equal to the distance between the holes in the arms of the blocks, or the holes in the wrought iron bars. In the middle of the upper and of the under side of each end may be observed a square prominence, more lightly shaded than the rest. These projections also advance a little beyond the flat of the shoulders, forming between them a shallow notch about an inch deep, which receives the iron of the arms, where they abut on each other, and thus give an additional firmness to the joint. The manner in which the arms are thus grasped by these notches in the bridles is more distinctly seen in fig. 4, at the letter H, in the middle of the upper rail.

The rib having been all trimmed and put together, so as to form the exact curve, the bolts are all taken out, and the horizontal bridles are then set on in their places, and the bolts are again put in and made fast by the forelocks. The bolts now pass through the shoulders of the bridles, through the wrought iron bars, and through the cast iron arm that is between them, and the forelocks bind all fast together. The manner in which this connection is completed is distinctly seen in fig. 4, which shows in perspective a double block in front, and a single block behind it. The abutting joints of the two front blocks are at the letters E, E, E; the holes in the shoulders of the horizontal cross pieces are at H.

48. This construction is beautifully simple, and very judicious. A vast addition of strength and of stiffness is procured by lodging the wrought iron bars in grooves

formed in the cast iron rails; and for this purpose it is of great importance to make the wrought iron bars fill the grooves completely, and even to be so tight as to require the force of the forelocks to draw them home to the bottom of the grooves. There can be no doubt but that this arch is able to withstand an enormous pressure, as long as the abutments from which it springs do not yield. Of this there is hardly any risk, because they are masses of rock, faced with about four or five yards (in some places only) of solid block masonry. The mutual thrusts of the frames are all in the direction of the rails, so that no part bears any transverse strain. We can hardly conceive any force that can overcome the strength of those arms by pressure or crushing them. The manner in which the frames are connected into one rib effectually secures the abutting joints from slipping; and the accuracy with which the whole can be executed secures us against any warping or deviation of a rib from the vertical plane.

But when we consider the prodigious span of this arch, and reflect that it is only five feet thick, it should seem that the most perfect equilibration is indispensably necessary. It is but like a film, and must be so supple, that an overload on any part must have a great tendency to bend it, and to cause it to rise in a distant part; and this effect is increased by the very firmness with which the whole sticks together. The overloaded part acts on a distant part, tending to break it with all the energy of a long lever. This can be prevented only by means of the stiffness of the distant part. It is very true, the arch cannot break in the extrados except by tearing asunder the wrought iron bars which connect the blocks along the upper rail, and each of these requires more than a hundred tons to tear it asunder; yet an overload of five tons on any rib at its middle will produce this strain at twenty feet from the sides, supposing the sides held firm in their position. It were desirable, therefore, that something were done to stiffen the arch at the sides, by the manner of filling up the spandrels or space between the arch and the road-way. This is filled up in a manner that is extremely light and pleasing to the eye, namely, by large cast iron circles, which touch the extrados of the arch and touch the road-way. The road-way rests on them as on so many hoops, while they rest on the back of the arch, and also touch each other laterally. We cannot think that this contributes to the strength of the arch; for these hoops will be easily compressed at the points of contact, and, changing their shape, will oppose very little resistance. We think that this part of the arch might have been greatly stiffened and strengthened by connecting it with the road-way by trussed frames, in the same way that a judicious carpenter would have framed a roof. If a strong cast iron pillar had been made to rest on the arch at about 20 feet from the impost, and been placed in the direction of a radius, the top of this pillar might have been connected by a diagonal bar of wrought iron with the impost of the arch, and with the crown of the arch by another string or bar of the same materials. These two ties would cause the radial pillar to press strongly on the back of the arch, and they must be torn asunder before it could bend in that place in the smallest degree. Supposing them of the same dimensions as the bars in the arms, their position would give them near ten times the force for resisting the strain produced by an overload on the crown.

This beautiful arch contains only 260 tons of iron, of which about 55 are wrought iron. The superstructure is of wood, planked over a top. This floor is covered with a coating of chalk and tar, on which are laid the materials for the carriage road, consisting of marl, limestone, and gravel, with foot-ways of flag-stones at the sides. The weight of the whole did not exceed 1000 tons, whereas the lightest stone arch which could have been erected would have weighed 15,000. It was turned on a very light but stiff scaffolding, most judiciously constructed for the preservation of its form, and for allowing an uninterrupted passage for the numerous ships and small craft which frequent the busy harbour of Sunderland. The mode of framing the arch was so simple and easy that it was put up in ten days, without an accident; and when all was finished, and the scaffolding removed, the arch did not sensibly change its form. The whole work was executed in three years, and cost about L.26,000.

Appendix.

49. The excellence of the preceding article, written by the late Dr John Robison, Professor of Natural Philosophy in the University of Edinburgh, for the Supplement to the third edition of this work, may be inferred from the fact, that almost every later writer on mechanics has spoken of it with approbation, and borrowed more or less from it. (See Gregory's *Mechanics*, book i. chap. 6; Hutton's *Tracts*, vol. i., Bridges; Whewell's *Mechanics*, art. 72, &c.) There is however one part of the article, viz. the purely mathematical part, which must have been quite unintelligible as it originally appeared, because of its numerous typographical errors. These are here corrected, we believe for the first time. Even with this advantage, we fear it has rather a forbidding aspect to the student of modern mathematics, because of the very complicated diagram (see Plate LII. fig. 12) from which the differential equation of the equilibrated arch has been deduced. We shall therefore, as an appendix, treat of the equilibrated polygon and equilibrated arch upon the general principles of statics, and employ in this investigation only the most simple geometrical figures. The theory of the equilibrated arch cannot be delivered without employing the principles of the differential and integral calculus; but we shall endeavour to pass from the finite equation of the equilibrated polygon to the differential equation of the arch by the shortest and most direct road.

Equilibrated Polygon.

50. In Plate LIII. fig. 9, let ABCDED'C'B'A' be a polygon formed by beams or rods AB, BC, CD, DE, &c. of any length, movable about the points B, C, D, E, &c. as joints, and forming an equilibrium in a vertical plane by the mutual thrusts at the joints and by the weight of the beams, the extreme sides of the polygon being supposed supported or attached to fixed points. Let AB, BC, CD, be any three consecutive sides of the polygon: produce AB, DC, the extreme sides, until they meet in H. The beam BC is kept in its position by the thrusts of the adjoining beams AB, CD, in the directions BH, CH, and its own weight, which is equivalent to pressures or loads on the joints B, C, acting in a vertical direction. Let G be the point in BC, which is the centre of gravity of weights proportional to loads at B and C. By the principles of statics, the directions of these forces must pass through the same point; therefore G must be in a vertical line passing through H.

51. Draw BL, CK, perpendicular to the vertical H G. Let φ, φ', φ'', denote the angles which the lines AB, BC, CD, in their order, make with any horizontal line in the plane of the polygon; then

φ = angle HBL, φ' = GBL = GCK, φ'' = HCK:

also let w denote the load on the joint B, and w' the load on the joint C.

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By the nature of the centre of gravity,

$$w : w' = \mathrm{CG} : \mathrm{BG} = \mathrm{CK} : \mathrm{BL},$$

therefore $$w : w' = \frac{1}{\mathrm{BL}} : \frac{1}{\mathrm{CK}} = \frac{\mathrm{HG}}{\mathrm{BL}} : \frac{\mathrm{HG}}{\mathrm{CK}}:$$

Now $$\frac{\mathrm{HG}}{\mathrm{BL}} = \frac{\mathrm{HL}}{\mathrm{BL}} - \frac{\mathrm{GL}}{\mathrm{BL}} = \tan.\ \varphi - \tan.\ \varphi'$$

and $$\frac{\mathrm{HG}}{\mathrm{CK}} = \frac{\mathrm{GK}}{\mathrm{CK}} - \frac{\mathrm{HK}}{\mathrm{CK}} = \tan.\ \varphi' - \tan.\ \varphi'';$$

hence it appears that

$$w : w' = \tan.\ \varphi - \tan.\ \varphi' : \tan.\ \varphi' - \tan.\ \varphi''.$$

If w'' denote the load on the next joint D, and φ''' the angle which the line DE makes with the horizontal plane, it will appear in the same way that

$$w' : w'' = \tan.\ \varphi' - \tan.\ \varphi'' : \tan.\ \varphi'' - \tan.\ \varphi''',$$

and so on throughout the whole polygon: whence we have this important proposition:

The vertical pressures on any two joints of the polygon, whether adjoining or remote, are to one another as the differences of the tangents of the angles which the sides about the joints make with the plane of the horizon.

52. From this proposition we may infer, that if φ, φ' denote the angles which any two adjoining sides of the polygon make with the horizontal plane, and w the load on the joint at their intersection, then,

$$w = \mathrm{C}\ (\tan.\ \varphi - \tan.\ \varphi') \ldots\ldots\ldots\ldots (\mathrm{A});$$

and in this formula, C denotes some constant quantity, which is the same for all the angles of the polygon. This is the general equation of the equilibrated polygon; and it shows that the loads at the joints depend entirely on the angles which the beams make with the horizontal plane, and are independent of the lengths of the beams themselves.

Equilibrated Arch.

53. We shall next investigate the differential equation of an equilibrated arch, deducing it from the finite equation of the equilibrated polygon.

Let us suppose an equilibrated polygon of a very great number of sides (fig. 10), and that a curve ABC passes through all the joints: the sides of the polygon will then be chords in the curve; and as the number of these may be conceived to be greater than any assigned number, and each shorter than any given line, they may be regarded as elements of the curve, and as constituting it.

54. Let us suppose the curve ABC formed in this manner to be the intrados of an arch of a bridge, and that the extrados is the line MDN, which may be curved or straight. Let AC be the *span*, or greatest horizontal width of the arch, and BH, which bisects AC at right angles, its *rise* or height; also let BD be the thickness of the arch of the crown: draw a straight line EDF perpendicular to DH, and draw AE, CF perpendicular to EF.

Let Pp be any indefinitely small part of the intrados ABC. Draw PRQ perpendicular to the horizontal line EF, meeting the extrados in R, and rp parallel to RP; also draw PK perpendicular to DH, meeting rp in q, and PT touching the intrados in p; and, referring the two curves to the same axes DE, let us put

$x =$ DQ the common abscissa,
$y =$ PQ the ordinate of the intrados,
$v =$ RQ the ordinate of the extrados,
$\varphi =$ angle TPK made by the tangent and horizontal line PK,
$c' =$ DB the given value of y at the crown,
$c'' =$ AE the given value of y at either haunch.

Then, because Pp is a differential of the arc BP, we have P$q = dx$, and $pq = dy$.

55. The load on the arc BP is the gravitating matter between it and DR, the arc of the extrados immediately over it. This is expressed by the area BDRP; therefore the load on Pp, the differential of the arc, is $(y - v)dx$, the differential of that area.

We have put φ to denote the angle which a tangent at P makes with any horizontal line; similarly, let φ' denote the angle which a line touching the curve at p makes with a horizontal line. If now the curve be considered as a polygon of an infinite number of infinitely short sides, and the lines which touch the curve at P and p as the prolongations of two adjoining sides, then, by formula (A), sect. 52, the vertical pressure at their intersection will be C $(\tan.\ \varphi - \tan.\ \varphi')$. But these infinitely short touching lines may be regarded as forming Pp, the differential of the curve, the load on which we have found to be $(y - v)dx$; and, moreover, $\tan.\ \varphi - \tan.\ \varphi' = d(\tan.\ \varphi)$, the differential of the trigonometrical tangent of φ; therefore, the relation between the intrados and extrados will be expressed by this equation,

$$\mathrm{C}\ d(\tan.\ \varphi) = (y - v)dx.$$

Now in all curves, $\tan.\ \varphi = \frac{dy}{dx}$, and making dx constant, $d(\tan.\ \varphi) = \frac{d^2y}{dx}$, let us, to make the members of the equation homogeneous, put c^2 instead of C, which is always positive, and the above equation becomes

$$c^2 \frac{d^2y}{dx} = (y - v)dx;$$

and hence

$$\frac{d^2y}{dx^2} - \frac{y}{c^2} = -\frac{v}{c^2} \ldots\ldots\ldots\ldots (\mathrm{B}).$$

This differential equation, which is of the second order, and *linear*, or of the first degree, comprehends in it the whole theory of the equilibrated arch. We may now deduce from it the resolution of two problems.

Prob. 1. Having given the form of the intrados ABC, to find that of the extrados.

Prob. 2. Having given the nature of the extrados, to determine the intrados.

56. The first problem is easy, and may be resolved by the differential calculus.

Ex. Let the intrados ABC be a segment of a circle whose centre is O. Draw PO to the centre. Let φ=angle POB, and $a =$ PO the radius of the circle; then,

$$x = \mathrm{DQ} = \mathrm{PK} = a \sin.\ \varphi,$$
$$y = \mathrm{PQ} = \mathrm{BD} + \mathrm{BK} = c' + a\ (1 - \cos.\ \varphi),$$
$$dx = a \cos.\ \varphi\ d\varphi, \qquad dy = a \sin.\ \varphi d\varphi,$$
$$\frac{dy}{dx} = \frac{\sin.\ \varphi}{\cos.\ \varphi} = \tan.\ \varphi;\ \frac{d^2y}{dx} = \frac{d\varphi}{\cos.^2\varphi},$$
$$\frac{d^2y}{dx^2} = \frac{1}{a \cos.^3 \varphi} = \frac{\sec.^3 \varphi}{a}.$$

Now, by formula (B),

$$\frac{y - v}{c^2} = \frac{d^2y}{dx^2} = \frac{\sec.^3 \varphi}{a};$$

therefore $y - v = \frac{c^2}{a} \sec.^3 \varphi$.

But when $x = 0$, then $v = 0$, $y = c'$, $\varphi = 0$, and $\sec.\ \varphi = 1$; therefore $c' = \frac{c^2}{a}$ and $c^2 = ac'$; hence we have

$$v - y = c' \sec.^3 \varphi.$$

This shows that the vertical line between the intrados and extrados is always proportional to the cube of the secant of the angle which the radius OP makes with the perpendicular; a conclusion which agrees with section 25 of the preceding article.

57. The second problem, viz. having given the nature

of the extrados, to find that of the intrados, is the more important of the two, and more difficult. Its solution requires the integral calculus; but the difficulty is no greater than that of finding the area of a curve whose equation is given. This can always be accomplished, if not in finite terms, at least by infinite series. We shall now give a general solution of the problem.

Lagrange has shown (*Théorie des Fonctions Analytiques*, chap. viii.) that the integration of the equation

$$\frac{d^2y}{dx^2}-\frac{y}{c^2}=X,$$

(where X denotes an explicit function of the variable x), can always be accomplished when two particular integrals of this other equation, viz.

$$\frac{d^2y}{dx^2}-\frac{y}{c^2}=0,$$

are known. Now $y=pe^{\frac{x}{c}}$ and $y=qe^{-\frac{x}{c}}$ are such integrals (p and q being arbitrary constants, and $e=2{\cdot}7182818$, the number whose Napierian logarithm is unity), as may be proved by differentiation; therefore, following Lagrange, to integrate the equation (B), viz.

$$\frac{d^2y}{dx^2}-\frac{y}{c^2}=-\frac{v}{c^2},$$

we assume

$$y=pe^{\frac{x}{c}}+qe^{-\frac{x}{c}}$$

for the complete integral equation; but now p and q are to be considered as functions of the variable x. To determine these, we differentiate, and get

$$\frac{dy}{dx}=\frac{1}{c}\left\{pe^{\frac{x}{c}}-qe^{-\frac{x}{c}}\right\}+e^{\frac{x}{c}}\frac{dp}{dx}+e^{-\frac{x}{c}}\frac{dq}{dx}:$$

Since p and q are indeterminate functions of x, we may assume that

$$e^{\frac{x}{c}}\frac{dp}{dx}+e^{-\frac{x}{c}}\frac{dq}{dx}=0,$$

and then we have

$$\frac{dy}{dx}=\frac{1}{c}\left\{pe^{\frac{x}{c}}-qe^{-\frac{x}{c}}\right\}:$$

Again, by differentiating, we find

$$\frac{d^2y}{dx^2}=\frac{1}{c^2}\left\{pe^{\frac{x}{c}}+qe^{-\frac{x}{c}}\right\}+\frac{1}{c}\left\{e^{\frac{x}{c}}\frac{dp}{dx}-e^{-\frac{x}{c}}\frac{dq}{dx}\right\}$$

$$=\frac{y}{c^2}+\frac{1}{c}\left\{e^{\frac{x}{c}}\frac{dp}{dx}-e^{-\frac{x}{c}}\frac{dq}{dx}\right\}.$$

This result, compared with equation (B), gives

$$\frac{1}{c}\left\{e^{\frac{x}{c}}\frac{dp}{dx}-e^{-\frac{x}{c}}\frac{dq}{dx}\right\}=-\frac{v}{c^2}.$$

From this and the equation

$$e^{\frac{x}{c}}\frac{dp}{dx}+e^{-\frac{x}{c}}\frac{dq}{dx}=0,$$

we obtain $\left(\text{putting } X=-\frac{v}{c^2}\right)$

$$\frac{dp}{dx}=\frac{c}{2}e^{-\frac{x}{c}}X,\qquad \frac{dq}{dx}=-\frac{c}{2}e^{\frac{x}{c}}X,$$

$$p=\frac{c}{2}\int e^{-\frac{x}{c}}Xdx+b;\ q=-\frac{c}{2}\int e^{\frac{x}{c}}Xdx+b'.$$

Here b and b' are arbitrary constants, and the integrals are supposed to be taken so as to vanish when $x=0$. The complete integral equation is now

(C)

$$y=be^{\frac{x}{c}}+b'e^{-\frac{x}{c}}+\frac{c}{2}\left\{e^{\frac{x}{c}}\int e^{-\frac{x}{c}}Xdx-e^{-\frac{x}{c}}\int e^{\frac{x}{c}}Xdx\right\}.$$

To determine the arbitrary constants b and b', we must consider that a tangent to the intrados at the vertex is perpendicular to the vertical DH; therefore, when $x=0$, then $\frac{dy}{dx}=0$; but from the equation just found we get

$$\frac{dy}{dx}=\frac{1}{c}\left\{be^{\frac{x}{c}}-b'e^{-\frac{x}{c}}\right\}+\tfrac{1}{2}\left\{e^{\frac{x}{c}}\int e^{-\frac{x}{c}}Xdx+e^{-\frac{x}{c}}\int e^{\frac{x}{c}}Xdx\right\}.$$

Now, when $x=0$, then $e^{\frac{x}{c}}=1$, and $e^{-\frac{x}{c}}=1$; and by hypothesis the integrals $\int e^{\frac{x}{c}}Xdx$, $\int e^{-\frac{x}{c}}Xdx$ in this particular case vanish; therefore, when $x=0$, the last equation becomes $0=b-b'$, so that $b'=b$. But again, in the general equation (C), when $x=0$, then $y=c'$; therefore we have also $c'=2b$ and $b=\frac{1}{2}c'$. On the whole, the equation of the extrados is

(D)

$$y=\frac{c'}{2}\left\{e^{\frac{x}{c}}+e^{-\frac{x}{c}}\right\}+\frac{c}{2}\left\{e^{\frac{x}{c}}\int e^{-\frac{x}{c}}Xdx-e^{-\frac{x}{c}}\int e^{\frac{x}{c}}Xdx\right\};$$

the integrals being taken so as to vanish when $x=0$. We have thus brought the solution to depend on the integration of the two differentials

$$e^{\frac{x}{c}}Xdx,\quad e^{-\frac{x}{c}}Xdx,$$

which in fact will only differ in their sign, because the branches of the extrados on opposite sides of the vertical are exactly alike, and therefore the substitution of $-x$ for $+x$ will not change the sign of u nor of X. Now this integration can always be effected by known methods, therefore the second problem may be regarded as completely resolved.

57. *Example.* Let us suppose that the extrados is a horizontal straight line EF.

The line PT being supposed to touch the curve, let us as before put

$$c'=\text{DB},\ c''=\text{EA},\ s=\text{DE},$$
$$x=\text{DQ},\ y=\text{PQ},\ \varphi=\text{angle TPK}.$$

In this case $v=0$ and $X=0$, and the equation of the curve is simply

$$y=\frac{c'}{2}\left\{e^{\frac{x}{c}}+e^{-\frac{x}{c}}\right\}.$$

This case of the general problem has been resolved in sect. 25; the equation of the curve is, however, here given under a different form. We shall now deduce from it a formula for logarithmic calculation.

In all curves, $\tan.\varphi=\frac{dy}{dx}$; in the present case

$$\tan.\varphi\left(=\frac{dy}{dx}\right)=\frac{c'}{2c}\left\{e^{\frac{x}{c}}-e^{-\frac{x}{c}}\right\}:$$

Let ψ be such an angle that

$e^{\frac{x}{c}}=\tan.(45^\circ+\frac{1}{2}\psi)$, then $e^{-\frac{x}{c}}=\tan.(45-\frac{1}{2}\psi)$. Hence, by the arithmetic of sines (ALGEBRA, sect. 244, (K) and sect. 240, (C) No. 1),

$$e^{\frac{x}{c}}+e^{-\frac{x}{c}}=\frac{1}{\cos.(45^\circ+\frac{1}{2}\psi)\cos.(45^\circ-\frac{1}{2}\psi)}=\frac{2}{\cos.\psi}=2\sec.\psi$$

$$e^{\frac{x}{c}}-e^{-\frac{x}{c}}=\frac{\sin.\psi}{\cos.(45^\circ+\frac{1}{2}\psi)\cos.(45^\circ-\frac{1}{2}\psi)}=\frac{2\sin.\psi}{\cos.\psi}=2\tan.\psi$$

Arch || Archangel.

Also, by the theory of logarithms (ALGEBRA, sect. xix.),

$$\frac{x}{c}\log.\,e = \log.\frac{\tan.\,(45^\circ + \frac{1}{2}\psi)}{\text{rad.}} = \log.\tan.\,(45^\circ + \tfrac{1}{2}\psi) - 10.$$

From these expressions we obtain the relation of the three principal elements of the curve, viz. φ, x, y, as follows:

$$\tan.\,\psi = \frac{c}{c'}\tan.\,\varphi \quad\ldots\ldots(1)$$

$$x = \frac{c}{\log.\,e}\left\{\log.\tan.\,(45^\circ + \tfrac{1}{2}\psi) - 10\right\} \ldots(2)$$

$$y = \frac{c'}{\cos.\psi} = c'\sec.\,\psi \quad\ldots\ldots(3)$$

But before these formulæ can be applied, the value of c must be known. To find this, let α denote the value of ψ when $x = s$ and $y = c''$; then equations (3) and (2) become

$$c'' = \frac{c'}{\cos.\,\alpha}$$

$$s = \frac{c}{\log.\,e}\left\{\log.\tan.\,(45^\circ + \tfrac{1}{2}\alpha) - 10\right\}$$

From these we obtain

$$\cos.\,\alpha = \frac{c'}{c''} \quad\ldots\ldots(4)$$

$$c = \frac{\log.\,e}{\log.\tan.(45^\circ + \frac{1}{2}\alpha) - 10}\,s \quad\ldots\ldots(5)$$

These formulæ determine c, and this known, the values of x and y corresponding to any proposed value of φ may be readily found from formulæ (1) (2) and (3).

58. We may also determine y directly from x without φ by eliminating $\frac{c}{\log.\,e}$ by formulæ (2) and (5); we have then, to determine y from x, these formulæ,

$$\cos.\,\alpha = \frac{c'}{c''} \quad\ldots\ldots(a)$$

$$\log.\tan.(45^\circ + \tfrac{1}{2}\psi) = 10 + \frac{x}{s}\left\{\log.\tan.(45^\circ + \tfrac{1}{2}\alpha) - 10\right\} \quad (b)$$

$$y = \frac{c'}{\cos.\psi} \quad\ldots\ldots(c)$$

1. As an example, let us take the case of Blackfriars Bridge, for which a table of corresponding values of x and y has been given, sect. 26. Here the span is 100 feet, the height or rise forty feet, and the thickness at the crown six feet; and first, let it be required to find the ordinate y, when $x = 20$ feet; we have now

$$s = 50,\ c' = 6,\ c'' = 46,\ x = 20,\ \frac{x}{s} = \frac{20}{50}.$$

Logarithmic Calculation.

$c' = 6$	0·7781512
$c'' = 46$	1·6627578
$\cos.\,(\alpha = 82^\circ\ 30'\ 19'')$	9·1153934
$\log.\tan.\,(45^\circ + \frac{1}{2}\alpha = 86^\circ\ 15'\ 9''{\cdot}5) - 10 =$	1·1837773
To	10·0000000
add $\frac{20}{50} \times 1.1837773 =$	0·4735109
$\tan.\,(45^\circ + \frac{1}{2}\psi = 71^\circ\ 25'\ 18'')$	10·4735109
$\cos.\,(\psi = 52^\circ\ 50'\ 36'')$	9·7810344
$y = \frac{c'}{\cos.\psi} = 9{\cdot}9338$ feet	0·9971168

The greater part of the above calculation serves for all the values of x, and need not be repeated in constructing a table of the ordinates.

2. Let it be required to find y when $x = 32$ feet.

To	10·0000000
add $\frac{32}{50} \times 1{\cdot}1837773 =$	0·7576175
$\tan.\,(45^\circ + \frac{1}{2}\psi = 80^\circ\ 5'\ 18'')$	10·7576175
$c' = 6$	0·7781512
$\cos.\,(\psi = 70^\circ\ 10'\ 36'')$	9·5303431
$y = 17{\cdot}6933$ feet	1·2478081

In this way may all the numbers in the table of sect. 26. be computed with greater expedition than by the formula given there.

The value of φ to each value of x may be found from formulæ (5) and (1) of last article. (R.)

ARCHÆUS, or ARCHEUS. See ARCHEUS.

ARCHANGEL, a Russian government or stadtholdership in the north of the eastern hemisphere of the globe; for though the city as well as the circle of the same name is comprehended in Europe, yet the government extends, according to Russian division, over great part of Asia. It is bounded on the north by the Frozen Ocean and White Sea; on the east by Tobolsk; on the south-east by Wologda; on the south-west by Olonez, of which a narrow part extends to the White Sea, and separates it from Finland; on the west by Finland; and on the north-west by Norway: but besides these boundaries there are some islands in the White Sea, and the great island Nova Zembla in the Frozen Ocean. The whole extent is 346,120 square miles, or 18,000 square miles more than the kingdom of France, comprehending 41 degrees of longitude, from 27. 54. to 69. 13., and 16½ of latitude, from 61. 23. to 78. 4. The climate, though not all alike, is universally raw and cold. Up to the latitude of 65° the spring is moist, with frost at nights; the summer is short, with long but foggy days; the autumn is moist, and the winter begins early. The trees, however, grow, and the rye ripens. The rivers cease to flow from October to April. Between the 65th and 47th degrees there are some trees, but dwarfish; corn does not ripen; and animals scarcely endure the temperature. Beyond 67° is a more arctic climate, short summer, long winter, and the soil always frozen below the surface. The rivers are closed in September, and scarcely thaw before July. Though oats and rye grow up to the 65°, yet beyond that the chief subsistence depends on the chase and the fisheries; but even in the most southern parts the bark of trees is mixed with corn to eke out the scanty products of the harvest. The province contains seven cities or towns, and 220 parishes. The inhabitants are Russians, Samoieds, Laplanders, or Permijaks, whose number it is difficult to ascertain. By the latest accounts we have been able to obtain, the males, exclusive of the burghers, were, in 1783, 80,546; the whole may be about 170,000.

ARCHANGEL, a circle in the Russian government of the same name, through the centre of which the Dwina runs. It produces some little corn, and turnips, radishes, cabbages, onions, and garlic. The cattle are tolerable, and their calves are in great request both in Petersburg and

Moscow. The inhabitants are all of the Russian race, and are seated, besides the capital, in four parishes, and three islands in the White Sea.

ARCHANGEL, a city, the capital of the government and circle of the same name, is situated on the Dwina where that river flows into the White Sea, and forms the Bay of Dwinskaja. The city is fortified in a very antique manner. All the houses but one are of wood, and the streets are planked instead of being paved. The churches are eleven Greek, and one each for Lutherans and Calvinists. There are a gymnasium, a seminary for priests, an hospital, and 1300 houses, with about 8000 inhabitants, who depend chiefly on foreign commerce. The harbour is good, but only accessible from July to September. The ships that repair to it are generally of 300 tons burden, mostly British, but some from the Netherlands and the Hans towns. The way to this port was first discovered by the English in the year 1553, since which it has gradually increased in commercial importance. In the year 1819 the arrivals of vessels were 305; the imports amounted to 442,403 rubles, the exports to 6,031,088: the former have doubled, and the latter tripled, since the year 1803. The chief exports are, corn, linseed, train-oil, tar, tallow, peltry, wax, honey, mats, linen, bar iron, and copper, the greater part of which is brought from a great distance, some by the Dwina, and some in the winter on sledges. The imports consist chiefly of sugar and other colonial productions, wine, and manufactured goods. The commercial establishments are chiefly branches of mercantile houses of Petersburg, or of English, German, or Dutch merchants residing here. It is in long. 38. 41. 48. E. and lat. 64. 31. 40. N.

ARCHANGEL, an angel occupying the eighth rank in the celestial hierarchy.

ARCHBISHOP, the name of a church dignitary of the first class. Archbishops were not known in the East till about the year 320; and though there were some soon after this who had the title, yet that was only a personal honour, by which the bishops of considerable cities were distinguished. It was not till of late that archbishops became metropolitans, and had suffragans under them. Athanasius appears to be the first who used the title *Archbishop*, which he gave occasionally to his predecessor; Gregory Nazianzen, in like manner, gave it to Athanasius; not that either of them was entitled to any jurisdiction, or even any precedence, in virtue of it. Among the Latins, Isidore Hispalensis is the first that speaks of archbishops. He distinguishes four orders or degrees in the ecclesiastical hierarchy, viz. patriarchs, archbishops, metropolitans, and bishops.

The archbishop, beside the inspection of the bishops and inferior clergy in the province over which he presides, exercises episcopal jurisdiction in his own diocese. He is guardian of the spiritualities of any vacant see in his province, as the king is of the temporalities, and exercises ecclesiastical jurisdiction in it. He is entitled to present by lapse to all the ecclesiastical livings in the disposal of his diocesan bishop, if not filled within six months. He has likewise a customary prerogative, upon consecrating a bishop, to name a clerk or chaplain, to be provided for by such bishop; in lieu of which it is now usual to accept an option. He is said to be enthroned when vested in the archbishopric, whereas bishops are said to be installed.

The ecclesiastical government of England is divided into two provinces, viz. Canterbury and York. Canterbury has the following suffragan bishoprics appertaining to it: St Asaph, Bangor, Bath and Wells, Bristol, Chichester, Lichfield and Coventry, St Davids, Ely, Exeter, Gloucester, Hereford, Llandaff, Lincoln, London, Norwich, Oxford, Peterborough, Rochester, Salisbury, Winchester, and Worcester. To York appertain the bishoprics of Carlisle, Chester, and Durham; to which may be added the bishopric of Sodor and Man, whose bishop is not a lord of parliament.

The archbishop of Canterbury had anciently, viz. till the year 1152, jurisdiction over Ireland as well as England, and was styled a *patriarch*, and sometimes *alterius orbis papa*, and *orbis Britannici pontifex*. Matters were done and recorded in his name thus,—*Anno pontificatus nostri primo*, &c. The first archbishop of Canterbury was Austin, appointed by King Ethelbert on his conversion to Christianity, about the year 598. He was also *legatus natus*. He even enjoyed some special marks of royalty; as to be patron of a bishopric, which he was of Rochester; and to make knights, coin moneys, &c. The archbishop is still the first peer of England, and the next to the royal family, having precedence of all dukes and all great officers of the crown. It is his privilege, by custom, to crown the kings and queens of this kingdom. He may retain and qualify eight chaplains, whereas a duke is allowed by statute only six. He has, by common law, the power of probate of wills and testaments, and granting letters of administration. He has also a power to grant licences and dispensations in all cases formerly sued for in the court of Rome, and not repugnant to the law of God. He accordly issues special licences to marry, to hold two livings, &c. and he exercises the right of conferring degrees. He also holds several courts of judicature; as court of arches, court of audience, prerogative court, and court of peculiars.

The archbishop of York has the like rights in his province as the archbishop of Canterbury. He has precedence of all dukes not of the royal blood, and of all officers of state except the lord high chancellor. He has also the rights of a count palatine over Hexhamshire. The first archbishop of York was Paulinus, appointed by Pope Gregory about the year 622. He had formerly jurisdiction over all the bishops of Scotland; but in the year 1470 Pope Sextus IV. created the bishop of St Andrews archbishop and metropolitan of all Scotland.

Scotland, whilst episcopacy prevailed in that country, had two archbishops, of St Andrews and Glasgow, the former of which was accounted the metropolitan, and, even before it arrived at the dignity of an archbishopric, resisted with great spirit all the attempts of the archbishops of York in England to become the metropolitans of Scotland. The sees of Argyll, Galloway, and the Isles, were suffragans to Glasgow; all the others in the kingdom to St Andrews.

Ireland has four archbishops—of Armagh, Dublin, Cashel, and Tuam; the first of which is primate of all Ireland.

ARCHBISHOPRIC, in *Ecclesiastical Geography*, a province subject to the jurisdiction of an archbishop.

ARCHBUTLER, one of the great officers of the German empire, who presents the cup to the emperor on solemn occasions. This office belongs to the king of Bohemia.

ARCHCHAMBERLAIN, an officer of the empire, much the same with the great chamberlain in England. The elector of Brandenburg was appointed by the golden bull archchamberlain of the empire.

ARCHCHANCELLOR, a high officer, who in ancient times presided over the secretaries of the court. Under the first two races of the kings of France, when their territories were divided into Germany, Italy, and Arles, there were three archchancellors; and hence the three archchancellors still subsisting in Germany—the archbishop of Mentz being archchancellor of Germany, the archbishop of Cologn, and the archbishop of Treves.

ARCHCHANTER, the president of the chanters of a church.

ARCHCOUNT, a title formerly given to the earl of Flanders on account of his great power and riches.

ARCHDEACON, an ecclesiastical dignitary or officer, next to a bishop, whose jurisdiction extends either over the whole diocese or only a part of it. He is usually appointed by the bishop himself, and has a kind of episcopal authority, originally derived from the bishop, but now independent and distinct from his. He therefore visits the clergy, and has his separate court for punishment of offenders by spiritual censures, and for hearing all other causes of ecclesiastical cognizance. There are 60 archdeacons in England.

Archdeacon's Court is the most inferior court in the whole ecclesiastical polity. It is held, in the archdeacon's absence, before a judge appointed by himself, and called his official; and its jurisdiction is sometimes in concurrence with, sometimes in exclusion of, the bishop's court of the diocese. From hence, however, by statute 24, Henry VIII. cap. 12, there lies an appeal to that of the bishop.

ARCHDRUID, the chief or pontiff of the ancient druids of a nation.

ARCHDUKE, a title peculiar to the house of Austria, all the sons of which are archdukes, and the daughters archduchesses.

ARCHELAUS, a celebrated Greek philosopher, the disciple of Anaxagoras, flourished about 440 years before Christ. He read lectures at Athens, and did not depart much from the opinions of his master. He taught that there was a double principle of all things, namely, the *expansion* and *condensation* of the air, which he regarded as infinite. Heat, according to him, was in continual motion. Cold was ever at rest. The earth, which was placed in the midst of the universe, had no motion. It originally resembled a wet marsh, but was afterwards dried up; and its figure, he said, resembled that of an egg. Animals were produced from the heat of the earth, and even men were formed in the same manner. All animals have a soul, which was born with them, but the capacities of which vary according to the structure of the organs of the body in which it resides. Socrates, the most illustrious of his disciples, was his successor.

Archelaus, the son of Herod the Great, was declared king of Judea the second year after the birth of Christ. He put to death 3000 persons before he went to Rome to be confirmed by Augustus. However, that emperor gave him half of what had been possessed by his father; but at length, on fresh complaints exhibited against him by the Jews, he banished him to Vienne in Gaul, A. D. 6, where he died.

Archelaus, the son of Apollonius, one of the greatest sculptors of antiquity, was a native of Ionia, and is thought to have lived in the time of the emperor Claudius. He executed in marble the apotheosis of Homer. Kircher, Spanheim, and several other learned antiquaries, have given a description and explication of this work.

ARCHENA, a town of Murcia, in Spain. It is situated on the river Segura, at the eastern extremity of the delicious valley of Ricote, and celebrated for its thermal springs. The waters retain a uniform heat of 41° of Reaumur, or 112° of Fahrenheit. These springs are much resorted to, though the situation is most melancholy, and the accommodations for invalids very bad.

ARCHERS, a kind of militia or soldiery armed with bows and arrows. The word is formed of *arcus*, a bow; whence *arcuarius*, and even *arquis* and *arquites*, as they are also denominated in the corrupt state of the Latin tongue. Archers were much employed in former times; but they are now laid aside, excepting in Turkey and some of the eastern countries. As an exercise, the practice of archery is still kept up in many places.

ARCHERY, the art or exercise of shooting with a bow and arrow.

In most nations the bow was anciently the principal implement of war, and by the expertness of the archers alone was often decided the fate of battles and of empires. In this island archery was greatly encouraged in former times, and many statutes were made for its advancement; whence it was that the English archers in particular became the best in Europe, and procured many signal victories.

The *Artillery Company* of London, though they have long disused the weapon, are the remains of the ancient fraternity of bowmen or archers. Artillery (*artillérie*) is a French term signifying *archery*, as the *king's bowyer* is in that language styled *artillier du roy;* and from that nation the English seem to have learnt at least the cross-bow archery. We therefore find that William the Conqueror had a considerable number of bowmen in his army at the battle of Hastings, when no mention is made of such troops on the side of Harold; and it is supposed that these Norman archers shot with the arbalest or cross-bow, in which formerly the arrow was placed in a groove, being termed in French a *quadrel*, and in English a *bolt*.

Of the time when shooting with the long-bow first began among the English, at which exercise they afterwards became so expert, there appear no certain accounts. Their chronicles do not mention the use of archery as expressly applied to the cross-bow or the long-bow till the death of Richard I., who was killed by an arrow at the siege of Limoges in Guienne, which Hemmingford mentions to have issued from a cross-bow. After this, which happened in 1199, there appear not upon record any notices of archery for nearly 150 years, when an order was issued by Edward III., in the 15th year of his reign, to the sheriffs of most of the English counties, for providing 500 white bows and 500 bundles of arrows, for the then intended war against France. Similar orders are repeated in the following years; with this difference only, that the sheriff of Gloucestershire is directed to furnish 500 painted bows, as well as the same number of white. The famous battle of Cressy was fought four years afterwards, in which our chroniclers state that we had 2800 archers, who were opposed to about the same number of the French; which, together with a circumstance to be immediately mentioned, seems to prove that by this time we used the long-bow, while the French archers shot with the arbalest. The circumstance alluded to is as follows:—Previously to the engagement there fell a very heavy rain, which is said to have much damaged the bows of the French, or perhaps rather the strings of them. Now the long-bow, when unstrung, may be most conveniently covered, so as to prevent the rain's injuring it; nor is there scarcely any addition to the weight from a case; whereas the arbalest is of a most inconvenient form to be sheltered from the weather. As, therefore, in the year 1342, orders were issued to the sheriffs of each county to provide 500 bows, with a proper proportion of arrows, it seems probable that these were long-bows, and not the arbalest.

At the above-mentioned battle the English ascribed their victory chiefly to the archers. The battle of Poictiers was fought in 1356, and gained by the same means.

Sometimes the archers gained great victories without even the least assistance from the men at arms; as particularly the decisive victory over the Scots at Homildon in 1402. In that bloody battle the men at arms did not strike a stroke, but were mere spectators of the valour and victory of the archers. The earl of Douglas, who com-

manded the Scotish army in that action, enraged to see his men falling thick around him by showers of arrows, and trusting to the goodness of his armour, which had been three years in making, accompanied by about 80 lords, knights, and gentlemen, in complete armour, rushed forward and attacked the English archers sword in hand. But he soon had reason to repent his rashness. The English arrows were so sharp and strong, and discharged with so much force, that no armour could repel them. The earl of Douglas, after receiving five wounds, was made prisoner; and all his brave companions were either killed or taken. Philip de Comines acknowledges, what our own writers assert, that the English archers excelled those of every other nation; and Sir John Fortescue says again and again, "that the might of the realme of England standyth upon archers." The superior dexterity of their archers gave the English a great advantage over their capital enemies the French and Scots. The French depended chiefly on their men at arms, and the Scots on their pikemen; but the ranks of both were often thinned and thrown into disorder by flights of arrows before they could reach their enemies.

James I. of Scotland, who had seen and admired the dexterity of the English archers, and who was himself an excellent archer, endeavoured to revive the exercise of archery among his own subjects, by whom it had been too much neglected. With this view he procured the following law to be made in his first parliament, in 1424, immediately after his return to Scotland: "That all men might busk thame to be archares fra the be 12 years of age; and that at ilk ten punds worth of land thair be made bow markes, and speciallie near paroche kirks, quhairn upon halie dayis men may cum, and at the leist schute thryse about, and have usage of archarie; and whasa usis not archarie, the laird of the land sal rais of him a wedder; and giff the laird raisis not the said pane, the king's shiref, or his ministers, sal rais it to the king." But his death prevented the effectual execution of this law.

There is not found any act of parliament of Henry V. in relation to archery, and all the orders of Rymer till the battle of Agincourt relate to great guns, from which he seems at first to have expected more considerable advantage than from the training of bowmen. It should seem, however, that this sort of artillery, from its unwieldiness, bad and narrow roads, together with other defects, was as yet but of little use in military operations. In the year 1417 this king therefore ascribes his victory at Agincourt to the archers, and directs the sheriffs of many counties to pluck from every goose six wing-feathers for the purpose of improving arrows, which are to be paid for by the king.

In 1421, though the French had been defeated both at Cressy, Poictiers, and Agincourt, by the English archers, yet they still continued the use of the cross-bow; for which reason Henry V., as duke of Normandy, confirms the charters and privileges of the balistarii, who had been long established as a fraternity in his city of Rouen.

In the fifth of Edward IV. an act passed, that every Englishman, and Irishman dwelling with Englishmen, shall have an English bow of his own height, which is directed to be made of yew, wych, hazel, ash, or awburne, or any other reasonable tree, according to their power. The next chapter also directs that butts shall be made in every township, which the inhabitants are obliged to shoot up and down every feast day, under the penalty of a halfpenny when they shall omit this exercise.

In the 14th year, however, of this same king, it appears by Rymer's *Fœdera*, that 1000 archers were to be sent to the duke of Burgundy, whose pay is settled at sixpence a day, which was a considerable sum in those times, when the value of money was so much higher than it is at present. This circumstance seems to prove very strongly the great estimation in which archers were still held. In the same year Edward, preparing for a war with France, directs the sheriffs to procure bows and arrows, "as most specially requisite and necessary."

On the war taking place with Scotland, eight years after this, Edward provides both ordnance and archers; so that though the use of *artillery*, as we now term it, was then gaining ground, yet that of the bow and arrow was not neglected.

Richard III., by his attention to archery, was able to send 1000 bowmen to the duke of Bretagne; and he availed himself of the same troops at the battle of Bosworth.

During the reign of Henry VII., however, there appears no order relative to gunpowder or artillery; while, on the other hand, in 1488, he directs a large levy of archers to be sent to Brittany, and that they shall be reviewed before they embark. In the 19th year of his reign, the same king forbids the use of the cross-bow, because "the long-bow had been much used in this realm, whereby honour and victory had been gotten against outward enemies, the realm greatly defended, and much more the dread of all Christian princes, by reason of the same."

During the reign of Henry VIII. several statutes were made for the promotion of archery. The 8th Eliz. c. 10, regulates the price of bows; and the 13th Eliz. c. 14, enacts that bow-staves shall be brought into the realm from the Hans Towns and the eastward; so that archery still continued to be an object of attention in the legislature.

In Rymer's *Fœdera* there is neither statute nor proclamation of James I. on this head; but it appears, by Dr Birch's life of his son (Prince Henry), that at eight years of age he learned to shoot both with the bow and gun, while at the same time this prince had in his establishment an officer who was styled *bow-bearer*. The king granted a second charter to the Artillery Company, by which the powers they had received from Henry VIII. were considerably extended.

Charles I. appears, from the dedication of a treatise entitled *The Bowman's Glory*, to have been himself an archer; and in the eighth year of his reign he issued a commission to the chancellor, lord mayor, and several of the privy council, to prevent the fields near London being so inclosed as to "interrupt the necessary and profitable exercise of shooting;" as also to lower the mounds where they prevented the view from one mark to another.

Catharine of Portugal, queen to Charles II., seems to have been much pleased with the sight at least of this exercise; for in 1676, by the contributions of Sir Edward Hungerford and others, a silver badge for the marshal of the fraternity was made, weighing 25 ounces, and representing an archer drawing the long-bow (in the proper manner) to his ear, with the following inscription: *Reginæ Catharinæ Sagittarii.* The supporters are two bowmen, with the arms of England and Portugal. In 1682 there was a most magnificent cavalcade and entertainment given by the Finsbury archers, when they bestowed the titles of "Duke of Shoreditch," "Marquis of Islington," &c. upon the most deserving. Charles II. was present upon this occasion.

So late as the year 1753 targets were erected in the Finsbury fields during the Easter and Whitsun holydays, when the best shooter was styled captain for the ensuing year, and the second lieutenant.

Before the introduction of fire-arms the enemy could only be struck at a distance by slings, the bow used by the ancients, or the cross-bow; to all which the English long-bow was infinitely superior. As for slings, they never have been used in the more northern parts of Eu-

Archery. rope by armies in the field; nor does their use indeed seem to have been at all convenient or extensively practicable, for two principal reasons: in the first place, slingers cannot advance in a compact body, on account of the space to be occupied by this weapon in its rotatory motion; in the next place, the weight of the stones to be carried must necessarily impede the slingers greatly in their movements. The bow of the ancients, again, as represented in all their reliefs, was a mere toy compared with that of our ancestors; it was therefore chiefly used by the Parthians, whose attacks, like those of the present Arabs, were desultory. As for the cross-bow, it is of a most inconvenient form for carriage, even with the modern improvements; and, in case of rain, could not easily be secured from the weather. After the first shot, moreover, it could not be recharged under a considerable time, whilst the bolts were also heavy and cumbersome. The English long-bow, on the other hand, together with the quiver of arrows, was easily carried by the archer, as easily secured from the rain, and recharged almost instantaneously. It is not therefore extraordinary, that troops who solely used this most effectual weapon should generally obtain the victory, even when opposed to much more numerous armies.

It may be urged, that these losses having been experienced by our enemies, must have induced them to practise the same mode of warfare. But it is thought that the long-bow was not commonly used even in England till the time of Edward III., when the victory at Cressy sufficiently proclaimed the superiority of that weapon. It required, however, so much training before the archer could be expert, that we must not be surprised if, soon afterwards, this military exercise was much neglected, as appears by the preambles of several ancient statutes. While the military tenures subsisted, the sovereign could only call upon his tenants during war, who therefore attended with the weapons they had been used to, and which required no previous practice. On the other hand, the English archers were obliged by acts of parliament, even in time of peace, to erect butts in every parish, and to shoot on every Sunday and holyday, after repairing perhaps to these butts from a considerable distance; while the expense of at least a yew bow is represented as being a charge to which they were scarcely equal. The kings and parliaments of this country having thus compelled the inhabitants to such training, the English armies had, it should seem, the same advantage over their enemies as the exclusive use of fire-arms would give us at present.

It appears, also, by what has been already stated, that the long-bow continued to be in estimation for more than two centuries after gunpowder was introduced, which probably arose from muskets being very cumbersome and unwieldy. It is well known that rapid movements are generally decisive of the campaign; and for such the archers were particularly adapted, because, as they could not be annoyed at the same distance by the weapons of the enemy, they had scarcely any occasion for armour. The flower of ancient armies likewise was the cavalry, against which the long-bow never failed to prevail; and hence the great number of French nobility who were prisoners at Cressy, Poictiers, and Agincourt; for being dismounted, if not wounded, whilst they were also clad in heavy armour, they could not make their escape. The same reason accounts for the English obtaining these signal victories with so inferior numbers; for the nobility and gentry thus becoming prisoners, the other parts of the French army made little or no resistance. No wonder, therefore, that in England the greatest anxiety was shown to promote the exercise of this most important weapon, and that so many statutes were made for that purpose.

In Scotland, also, little less attention, though apparently not with equal success, was shown to the encouragement of the art. In both kingdoms it was provided that the importers of merchandise should be obliged, along with their articles of commerce, to import a certain proportion of bows, bow-staves, and shafts for arrows. In both every person was enjoined to hold himself provided in bows and arrows, and was prescribed the frequent use of archery. In both a restraint was imposed upon the exercise of other games and sports, lest they should interfere with the use of the bow; for it was intended that people should be made expert in the use of it as a military weapon, by habituating them to the familiar exercise of it as an instrument of amusement. As there was no material difference between the activity and bodily strength of the two people, it might be supposed that the English and Scots wielded the bow with no unequal vigour and dexterity; but, from undoubted historical monuments, it appears that the former had the superiority, of which one instance has been already narrated. By the regulations prescribed in their statute-book for the practice of archery, we find that the English shot a very long bow, those who were arrived at their full growth and maturity being prohibited from shooting at any mark that was not distant upwards of 220 yards.

In the use of the bow, great dexterity as well as strength seems to have been requisite. Though we hear of arrows at Chevy Chase which were a yard long, yet it is by no means to be supposed that the whole band made use of such, or could draw them to the head. The regulation of the Irish statute of Edward IV., viz. that the bow should not exceed the height of the man, is allowed by archers to have been well considered; and as the arrow should be half the length of the bow, this would give an arrow of a yard in length to those only who were six feet high. A strong man of this size in the present times cannot easily draw above 27 inches, if the bow is of a proper strength to do execution at a considerable distance. At the same time it must be admitted, that as our ancestors were obliged by some of the old statutes to begin shooting with the long-bow at the age of seven, they might have acquired a greater sleight in this exercise than their descendants, though the latter should be allowed to be of equal strength.

As the shooting with the long-bow was first introduced in England, and practised almost exclusively for nearly two centuries, so it has occasioned a peculiar method of drawing the arrow to the ear and not to the breast. That this is contrary to the usage of the ancients is very clear from their reliefs, and from the tradition of the Amazons cutting off one of their paps, as it occasioned an impediment to their shooting. The Finsbury archer is therefore represented in this attitude of drawing to the ear, both in the *Bowman's Glory* and in the silver badge given by Catharine to the Artillery Company.

As to the distance to which an arrow can be shot from a long-bow with the best elevation of 45 degrees, that must necessarily depend much both upon the strength and sleight of the archer; but in general the distance was reckoned from eleven to twelve score yards. The butts for exercise, as above noticed, were directed to be distant upwards of 220 yards. There is indeed a tradition, that an attorney of Wigan in Lancashire, named Leigh, shot a mile in three flights; but the same tradition states that he placed himself in a very particular attitude, which cannot be used commonly in this exercise. According to Neade, an archer might shoot six arrows in the time of charging and discharging one musket.

The archers consider an arrow of from 20 to 24 drop weight to be the best for flight or hitting a mark at a con-

siderable distance, and that yew is the best material of which they can be made. As to the feathers, that of a goose is preferred: it is also wished that the bird should be two or three years old, and that the feather may drop of itself. Two out of three feathers in an arrow are commonly white, being plucked from the gander; but the third is generally brown or gray, being taken from the goose, and, from this difference in point of colour, informs the archer when the arrow is properly placed. From this most distinguished part, therefore, the whole arrow sometimes receives its name: and this, by the by, affords an explanation of the gray-goose wing in the ballad of Chevy Chase. Arrows were armed anciently with flint or metal heads, latterly with heads of iron: of these there were various forms and denominations. By an act of parliament made the 7th of Henry IV. it was enacted, That for the future all the heads for arrows and quarrels should be well boiled or brased, and hardened at the points with steel; and that every arrow-head or quarrel should have the mark of the maker: workmen disobeying this order were to be fined and imprisoned at the king's will, and the arrow-heads or quarrels to be forfeited to the crown.

Arrows were reckoned by sheaves, a sheaf consisting of 24 arrows. They were carried in a quiver, called also an *arrow-case*, which served for the magazine; arrows for immediate use were worn in the girdle. In ancient times phials of quicklime, or rather combustible matter, for burning houses or ships, were fixed on the heads of arrows, and shot from long-bows. This has been also practised since the use of gunpowder. Neade says he has shown by experience that an archer may shoot an ounce of fireworks upon an arrow twelve score yards. Arrows with wildfire, and arrows for fireworks, are mentioned among the stores at Newhaven and Berwick in the 1st of Edward VI.

The force with which an arrow strikes an object at a moderate distance may be conceived from the account given by King Edward VI. in his journal; wherein he says, that 100 archers of his guard shot before him two arrows each, and afterwards altogether; and that they shot at an oak board, which some pierced quite through and struck to the other board; divers pierced it quite through with the heads of their arrows, the board being well-seasoned timber: their distance from the mark is not mentioned.

To protect our archers from the attacks of the enemy's horse, they carried long stakes pointed at both ends: these they planted in the earth, sloping before them. In the first of Edward VI., 350 of these were in the stores of the town of Berwick, under the article of archers' stakes: there were also at the same time eight bundles of archers' stakes in Pontefract castle.

To prevent the bowstring from striking the left arm, the arm is covered with a piece of smooth leather, fastened on the outside of the arm—this is called a *bracer;* and to guard the fingers from being cut by the bowstring, archers wore shooting gloves. Chaucer, in his prologue to the Canterbury Tales, thus describes an archer of his day:

And he was cladde in cote and hode of grene.
A shefe of peacock arwes bright and kene
Under his belt he bare ful thriftily.
Wel coude he dresse his takel yemanly:
His arwes drouped not with fetheres lowe.
And in his hond he bare a mighty bowe.
A not-hed hadde he, with a broune visage.
Of wood-craft coude he wel alle the usage.
Upon his arme he bare a gaie bracer,
And by his side a swerd and a bokeler,
And on that other side a gaie daggere,
Harneised wel, and sharpe as point of spere:
A Cristofre on his brest of silver shene.
An horne he bare, the baudrik was of grene.
A forster was he sothely as I gesse.

Though archery continued to be encouraged by the king and legislature for more than two centuries after the first knowledge of the effects of gunpowder, yet by the latter end of the reign of Henry VIII. it seems to have been partly considered as a pastime. Arthur, the elder brother of Henry, is said to have been fond of this exercise, insomuch that a good shooter was styled Prince Arthur. We are also informed that he pitched his tent at Mile-End in order to be present at this recreation, and that Henry his brother also attended. When the latter afterwards became king, he gave a prize at Windsor to those who should excel in this exercise; and a capital shot having been made, Henry said to Barlow (one of his guards), "If you still win, you shall be duke over all archers." Barlow therefore having succeeded, and living in Shoreditch, was created duke thereof. Upon another occasion Henry and the queen were met by 200 archers on Shooter's hill, which probably took its name from their assembling near it to shoot at marks. This king likewise gave the first charter to the Artillery Company, in the 29th year of his reign, by which they are permitted to wear dresses of any colour except purple and scarlet—to shoot not only at marks, but birds, if not pheasants or herons, and within two miles of the royal palaces. They are also enjoined by the same charter not to wear furs of a greater price than those of the marten. The most material privilege, however, is that of indemnification for murder, if any person passing between the shooter and the mark is killed, provided the archers have first called out *fast*.

The following description of an archer, his bow, and accoutrements, is given in a MS. written in the time of Queen Elizabeth. "Captains and officers should be skilful of that most noble weapon, and to see that their soldiers according to their draught and strength have good bowes, well nocked, well strynged, every strynge whippe in their nocke, and in the myddes rubbed with wax, braser and shuting glove, some spare strynges trymed as aforesaid, every man one shefe of arrows, with a case of leather defensible against the rayne, and in the same fower and twentie arrowes, whereof eight of them should be lighter than the residue, to gall or astoyne the enemye with the hailshot of light arrows, before they shall come within the danger of the harquebuss shot. Let every man have a brigandine, or a little cote of plate, a skull or hufkyn, a mawle of leade of five foote in lengthe, and a pike, and the same hanging by his girdle, with a hook and a dagger; being thus furnished, teach them by musters to marche, shoote, and retire, keepinge their faces upon the enemy's. Sumtyme put them into great nowmbers, as to battell apparteyneth, and thus use them often times practised, till they be perfecte; ffor those men in battel ne skirmish can not be spared. None other weapon maye compare with the same noble weapon."

The long-bow, as already observed, maintained its place in our armies long after the invention of fire-arms; nor have there been wanting experienced soldiers who were advocates for its continuance, and who in many cases even preferred it to the harquebuss or musket. King Charles I. twice granted special commissions under the great seal for enforcing the use of the long-bow. The first was in the 4th year of his reign; but this was revoked by proclamation four years afterwards, on account of divers extortions and abuses committed under sanction thereof. The second, anno 1633, in the ninth year of his reign, to William Neade and his son, also named William, wherein the former is styled an ancient archer, who had presented to the king a warlike invention for uniting the use of the pike and bow, seen and approved by him and his council of war; whereof his majesty had granted them

Archery.

a commission to teach and exercise his loving subjects in the said invention, which he particularly recommended the chief officers of his trained bands to learn and practise; and the justices and other chief magistrates throughout England are therein enjoined to use every means in their power to assist Neade, his son, and all persons authorized by them, in the furtherance, propagation, and practice of this useful invention. Both the commissions and proclamation are printed at large in Rymer. At the breaking out of the civil war, the earl of Essex issued a precept, dated in November 1643, for stirring up all well-affected people towards the raising of a company of archers for the service of the king and parliament.

There are several societies of archers in England; but the most noted society of this kind now existing is

The Royal Company of Archers, the King's Body Guard for Scotland. The ancient records of this company having been destroyed by fire about the end of the 16th century, no authentic traces of its institution now remain; but, from entries found in some of the old national records, this company must be of great antiquity. It is believed that the Royal Company owes its origin to the commissioners appointed in the reign of James I. of Scotland for enforcing and overseeing the exercise of archery in different counties. These commissioners, who were men of rank and power, picked out from among the better classes under their cognizance, the most expert bowmen, formed them into a company, and upon perilous occasions they attended the king as his chief body guard; and in that situation they always distinguished themselves for their loyalty, courage, and skill in archery. The rank of King's Body Guard for Scotland was from tradition understood to be vested in the Royal Company, and they accordingly claimed the honour of acting as body guard to his majesty King George IV. on the occasion of his visit to Scotland in 1822. His majesty was graciously pleased to recognise their claim, and the Royal Company were thus established as the King's Body Guard for Scotland. They attended his majesty at court and on all state occasions during his residence in Scotland, and accompanied him on his visit to Hopetoun House, from whence he embarked for London. The captain-general has since been appointed gold stick for Scotland, and the Royal Company now forms part of the household.

It appears from the minutes of the Royal Company now extant, that an act of the privy council of Scotland was passed in 1677, conferring on them the name and title of "His Majesty's Company of Archers," and granting a sum of money for a piece of plate to be shot for in that year as a prize; but no *permanent* king's prize was established until 1788, when his majesty George III., as a mark of his royal patronage and favour, was pleased to grant a sum of money to be shot for annually, to be named the king's prize, and to become the property of the winner. The gainer is bound to purchase a piece of plate, on which must be inscribed the king's arms, and the date when the prize was gained.

During the revolution in 1688 the Royal Company were opposed to the principles then espoused; and for many years they had to forego their public parades, and the company in consequence had nearly been annihilated. On the accession of Queen Anne, however, their former splendour was revived; and in the year 1703 a royal charter was granted, confirming all their former rights and privileges, and conferring others upon them.

Thus the Royal Company continued to flourish for a number of years; but their attachment to the family of Stuart was the cause at various times of a temporary prosperity and decline. These unhappy differences having long since terminated, the Royal Company, which consists of the principal nobility and gentry of Scotland, are now more prosperous, and perhaps more dexterous in the art of archery, than at any former period in their history.

The prizes belonging to this Royal Company, and which are annually shot for, are, 1*st*, A silver arrow, given by the town of Musselburgh, which appears to have been shot for as early as the year 1603. The victor in this, as in the other prizes, except the king's prize, has the custody of it for a year, then returns it with a medal appended, on which are engraved any motto and device which the gainer's fancy dictates. 2*d*, A silver arrow, given by the town of Peebles A. D. 1626. 3*d*, A silver arrow, given by the city of Edinburgh A. D. 1709. 4*th*, A silver arrow, given by the town of Selkirk, which was shot for in 1819, after an interval of 144 years. 5*th*, A silver punch bowl, made of Scotish silver, at the expense of the company, A. D. 1720, to which a gold medal has annually been attached. This prize can only be gained by three consecutive ends; and if not won during the summer, it is shot for as an ordinary prize at the end of the season. 6*th*, A gold medal, made of pagodas, being part of the money paid by Tippoo Sultan at the treaty of Seringapatam, and presented to the Royal Company by Major James Spens. 7*th*, An elegant silver vase and gold medal, presented by General John Earl of Hopetoun, in commemoration of the visit of George IV. to Scotland in 1822, called the royal commemoration prize, and which is shot for on the king's birth-day annually. These prizes are all shot for at the distance of 180 yards. There is another prize, which was given by Sir George Mackenzie of Coul, Bart., to the Royal Company, to be shot for at the distance of 200 yards, and is called the "Saint Andrew prize." These prizes are shot for at rovers, and, with the exception of the silver bowl, are gained by the person who counts the greatest number of points in a given number of ends.

Besides the above, there is another prize shot for, at the distance of 100 yards, being an elegant silver bugle-horn, presented to the Royal Company by one of the general officers, Sir Henry Jardine, Knt., and was shot for on 9th April 1830 for the first time.

There are also two prizes contended for at butts, or point blank distance, being 100 feet. The first is called the goose. The ancient manner of shooting for this prize was, by building a living goose in a turf-butt, having the head only exposed to view; and the archer who first hit the head was entitled to have the goose as his reward, and bore the title of Captain Goose for the season. This barbarous custom has long since been laid aside; and in place of the goose's head a small glass globe is put into the butt, of about an inch in diameter, and the archer who breaks this is declared victor, and is entertained by the company at dinner. He wears a medal which was presented by Major Spens, also made of Tippoo Sultan's pagodas. The other butt prize is a gold medal, which is shot for on the last Saturday of January, February, and March, annually, and is gained by him who counts the greatest number of points in the three days shooting.

The affairs of the Royal Company are managed by a council, consisting of seven, who are chosen annually at a general meeting of the members. The council are vested with the power of receiving or rejecting candidates for admission, and of appointing the officers of the company, civil and military.

The Royal Company consists of about 500 members. There are weekly meetings of members at Edinburgh, in the Meadows, when they exercise themselves in shooting at butts and rovers; and in the adjoining ground they have a handsome building called Archer's Hall, erected within these 50 years, where they dine, and hold their elections and other meetings relative to the business of the company.

The field uniform of the Royal Company is of dark-green cloth, faced with black braiding, with a narrow stripe of crimson velvet in the centre. The hat is of the same colour, with a handsome medallion in front, and a plume of black feathers.

The Royal Company have two standards, which are very old. The first of these bears on one side Mars and Venus, encircled in a wreath of thistles, with this motto, "In peace and war." On the other side a yew-tree, with two men dressed and equipped as archers, encircled as the former; motto, "Dat gloria vires." The other standard displays on one side a lion rampant, gules on a field or, encircled with a wreath; on the top a thistle and crown; motto, "Nemo me impuno lacessit." On the reverse side St Andrew on the Cross, on a field argent; at the top a crown; motto, "Dulce pro patria periculum."

His present majesty King William IV. has presented the Royal Company of Archers, his Body Guard for Scotland, with new colours. The one combines both the old ones, with the words, "the Royal Company of Archers;" and the other bears the Royal Arms of Scotland, with the words, "King's Body Guard for Scotland." His majesty has also expressly confirmed the appointment of the Royal Company to be "the King's Body Guard for Scotland."

ARCHES COURT. See COURT OF ARCHES.

ARCHETYPE, the first model of a work, which is copied after to make another like it. Among minters it is used for the standard weight by which the others are adjusted. The archetypal world, among Platonists, means the world as it existed in the idea of God before the visible creation.

ARCHEUS (from αρχη, the principal, chief, or first mover), a sort of *primum mobile* set up by Helmont, to superintend the animal economy, and preserve it. It is akin to Plato's *anima mundi*. Hippocrates uses the words αρχαιη φυσις to signify the former healthy state before the attack of the disease.

ARCHIACOLYTHUS (from αρχος, *chief*, and ακολουθος, *minister*), an ancient dignity in cathedral churches, the ministers whereof were divided into four orders or degrees, viz. priests, deacons, subdeacons, and acolythi, each of which had their chiefs. The chief of the acolythi was called *archiacolythus*.

ARCHIATER, ARCHIATRUS, properly denotes chief physician of a prince who retains several. The word is formed of αρχη, *principium*, chief, and ιατρος, *medicus*, a physician.

ARCHIDAPIFER (from αρχος, and *dapifer*, sewer), or chief sewer, is a great officer of the empire. The elector of Bavaria is archidapifer. The palatine of the Rhine at one time pretended this office was annexed to his palatinate, but he has since desisted.

ARCHIDONA, a city of Spain, on a small stream which flows into the river Guadalorza, in the province of Granada. It is a well built town, with one church, five monasteries, and 5000 inhabitants, who derive their subsistence chiefly from the excellent oil which they make from their abundant olives.

ARCHIEROSYNES, in the *Grecian Antiquity*, a high priest vested with authority over the rest of the priests, and appointed to execute the more sacred and mysterious rites of religion.

ARCHIGALLUS, in *Antiquity*, the high priest of Cybele, or the chief of the eunuch priests of that goddess, called *Galli*.

ARCHIGERONTES (from αρχος, and γερων, *old*), in *Antiquity*, the chiefs or masters of the several companies of artificers at Alexandria. Some have mistaken the archigerontes for the arch-priests appointed to take the confession of those who were condemned to the mines.

ARCHIGUBERNUS, ARCHIGUBERNETA, or ARCHIGUBERNITES, in *Antiquity*, the commander of the imperial ship, or that which the emperor was aboard of. Some have confounded the office of archigubernus with that of *præfectus classis*, or admiral; but the former was under the command of the latter. Potter takes the proper office of the archiguberneta to have been, to manage the marine affairs, to provide commodious harbours, and order all things relating to the sailing of the fleet except what related to war. Archigubernus || Archilochus.

ARCHIL, ARCHILLA, ROCELLA, ORSIELLE, is a whitish moss which grows upon rocks, in the Canary and Cape de Verde Islands, and yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered. Those who prepare it for the use of the dyer grind it between stones, so as to thoroughly bruise, but not to reduce it into powder; and then moisten it occasionally with a strong spirit of urine, or urine itself mixed with quicklime. In a few days it acquires a purplish red, and at length a blue colour. In the first it is called *Archil;* in the latter, *Lacmus* or *Litmase*.

ARCHILOCHIAN, a term in poetry applied to a sort of verses, of which Archilochus was the inventor; consisting of seven feet, of which the first four are ordinarily dactyles, though sometimes spondees; the last three trochees.

ARCHILOCHUS, a famous Greek poet and musician, was, according to Herodotus, contemporary with Candaules and Gyges, kings of Lydia, who flourished about the 14th Olympiad, 724 years before Christ. But he is placed much later by modern chronologists, viz. by Blair 686, and by Priestley 660 years before Christ. He was born at Paros, one of the Cyclades. His father Telesicles was of so high a rank that he was chosen by his countrymen to consult the oracle at Delphi concerning the sending of a colony to Thasos—a proof that he was of one of the most distinguished families upon the island. However, he is said to have sullied his birth by an ignoble marriage with a slave called *Enipo*, of which alliance our poet musician was the fruit. Though Archilochus showed an early genius and attachment to poetry and music, these arts did not prevent his becoming a soldier; but in the first engagement at which he was present the young poet lost his buckler, though he saved his life by the help of his heels. "It it much easier," said he, "to get a new buckler than a new existence." This pleasantry, however, did not save his reputation; nor could his poetry or prayers prevail upon Lycambes, the father of his mistress, to let him marry his daughter, though she had been long promised to him.

According to Plutarch, there was no bard of antiquity by whom the two arts of poetry and music were so much advanced as by Archilochus. To him is attributed particularly the sudden transition from one rhythm to another of a different kind, and the manner of accompanying those irregular measures upon the lyre. Heroic poetry, in hexameter verse, seems to have been solely in use among the more ancient poets and musicians; and the transition from one rhythm to another, which lyric poetry required, was unknown to them; so that if Archilochus was the first author of this mixture, he might with propriety be styled the *Inventor of Lyric Poetry*, which after his time became a species of versification wholly distinct from heroic. To him is likewise ascribed the invention of *Epodes*. One of his hymns, written in honour of Hercules, acquired him the acclamations of all Greece; for he sung it in full assembly at the Olympic games, and had the satisfaction of receiving from the judges the crown of victory consecrated to real merit. This hymn or ode was afterwards sung in honour of every victor at Olympia who had no poet to celebrate his particular exploits.

Archimagus || Archimedes.

Archilochus was slain by one Callondax Corax, of the island of Naxos; who, though he did it in fight according to the laws of war, was driven out of the temple of Delphi, by command of the oracle, for having deprived of life a man consecrated to the Muses.

The names of Homer and Archilochus were revered and celebrated in Greece, as the two most excellent poets which the nation had ever produced. This appears from an epigram in the Anthologia; and from Cicero, who ranks him with poets of the first class, and in his Epistles tells us that the grammarian Aristophanes, the most rigid and scrupulous critic of his time, used to say that the longest poem of Archilochus always appeared to him the most excellent. Some fragments of his poems have been preserved. These may be seen in the Collection of Greek Poets published at Geneva in 1606, and in the *Analecta* of Brunck, vols. i. and iii.

ARCHIMAGUS, the high priest of the Persian Magi or worshippers of fire. Darius Hystaspes took upon himself the dignity of Archimagus; for Porphyry tells us he ordered, before his death, that, among the other titles, it should be engraven on his monument that he had been *Master of the Magi;* which plainly implies that he had borne this office among them, for none but the Archimagus was master of the whole sect. From hence it seems to have proceeded that the kings of Persia were ever after looked on to be of the sacerdotal tribe, and were always initiated into the sacred order of the Magi, before they took on them the crown, and were inaugurated into the kingdom.

ARCHIMANDRITE, in *Ecclesiastical History*, was a name given by the ancient Christians to what we now call an *abbot*. Father Simon observes, that the word *mandrite* is Syriac, and signifies a solitary monk.

ARCHIMEDES, the most celebrated of the ancient mathematicians, was born at Syracuse, in Sicily, about the year 180 before the Christian era. Hiero, king of Syracuse, deemed it an honour to have this philosopher for his relative and friend. History does not inform us to whom he was indebted for the rudiments of literature, but he flourished about 50 years after Euclid. It is reported that he was indebted to Egypt for much of his knowledge; but other accounts indicate that he conferred more knowledge than he received from that celebrated nation; and, in particular, Diodorus mentions that Egypt was indebted to him for the invention of the screw-pump for drawing off water: and the same author narrates that he was the inventor of several other useful machines, which conveyed his fame to every quarter of the globe. The following passage from Livy proves that he was dexterous both for the inventing of warlike machines, and also for his accurate observation of the heavenly bodies: "Unicus spectator cœli siderumque, mirabilior tamen inventor ac machinator bellicorum tormentorum," &c. lib. xxiv. cap. 34. It appears also that, in Cicero's time, he had become proverbial for his skill in solving problems. In a letter to Atticus, he informs him that he is now freed from a difficulty, which he termed an Archimedian problem, lib. xiii. ep. 28.

Vitruvius mentions a fact which proves Archimedes's knowledge in the doctrine of specific gravity. Hiero, the king, having given a certain quantity of gold wherewith to make a golden crown, and suspecting that the workmen had stolen part of the gold and substituted silver in its stead, he applied to Archimedes to employ his ingenuity in detecting the fraud. Ruminating upon this subject when he was bathing himself, he observed that he dislodged a quantity of water corresponding to the bulk of his own body; therefore, instantly quitting the bath with all the eagerness natural to an inventive mind upon a new discovery, he ran into the street naked, crying, Εὕρηκα! Εὕρηκα! *I have found it out! I have found it out!* Then taking one mass of gold and another of silver, each equal in weight to the crown, he carefully observed the quantity of fluid which they alternately displaced, when introduced in the same vessel full of water. Next he ascertained how much water was displaced by the crown when put into the same vessel full of water; and, upon comparing the three quantities together, he ascertained the exact proportions of gold and silver of which the crown was composed.

Archimedes was well acquainted with the mechanical powers. His celebrated saying with regard to the power of the lever has been often repeated,—"Give me a place to stand upon, and I will move the earth." In order to show Hiero the effect of mechanical powers, it is said that, aided by ropes and pulleys, he drew towards him a galley which lay on the shore manned and loaded; but the displays of his mechanical skill mentioned by Marcellus at the siege of Syracuse were long deemed almost incredible, until the after-improvements in mechanics have demonstrated them practicable. He harassed the vessels of the besiegers, both when they approached and kept at a distance from the city. When they approached, he sunk them by means of long and huge beams of wood; or, by means of grappling hooks placed at the extremity of levers, he hoisted up the vessels into the air, and dashed them to pieces either against the walls or the rocks. When the enemy kept at a distance, he employed machines which threw from the walls such a quantity of stones as shattered and destroyed their vessels. In short, his mechanical genius supplied strength and courage to the city, and filled the Romans with astonishment and terror. Until Buffon invented and framed a burning glass, composed of about 400 glass panes, capable of setting fire to wood at the distance of 200 feet, and of melting lead and tin at the distance of 120 feet, and silver at the distance of 50, the account of Archimedes's instrument for burning ships at a great distance by means of the rays of the sun was deemed fabulous and impossible.

But, however eminent for mechanical invention, he was still more eminent for the investigation of abstract truths, and the formation of conclusive demonstrations in pure geometry. Plutarch also mentions that Archimedes himself esteemed mechanical inventions greatly inferior in value to those speculations which convey irresistible conviction to the mind. His geometrical works afford numerous proofs of his success in this field of science. It is reported that he was often so deeply engaged in mathematical speculations, as both to neglect his food and the care of his person; and at the bath he would sometimes draw geometrical figures in the ashes, and sometimes upon his own body when it was anointed, according to the custom of that time. He valued himself so much upon the discovery of the ratio between the sphere and the containing cylinder, that, indifferent to all his other inventions, he ordered his friends to engrave upon his tomb a cylinder containing a sphere, with an inscription explanatory of its nature and use.

It must be extremely painful to every humane mind, but particularly to every lover of philosophic merit, to learn, that when Syracuse was taken by storm, Archimedes, being ignorant of that fact, was run through the body, when engaged in drawing a geometrical figure upon the sand. As Marcellus had given express orders that both his person and his house should be held sacred, this appears to have happened through ignorance, and therefore removes a great part of the odium from the Roman name. This mournful event happened in the 142d Olympiad, or 212 years before the Christian era. Marcellus, in the midst of his

triumph, lamented the death of Archimedes, conferred upon him an honourable burial, and took his surviving relations under his protection; but greater honour was conferred upon him when the philosopher of Arpinum, 140 years after, went in search of his long-neglected tomb. Hence, says Cicero, "I diligently sought to discover the sepulchre of Archimedes, which the Syracusans had totally neglected, and suffered to be overgrown with thorns and briers. Recollecting some verses said to be inscribed on the tomb, which mentioned that on the top was placed a sphere with a cylinder, I looked round me upon every object at the Agrigentine gate, the common receptacle of the dead. At last I observed a little column which just rose above the thorns, upon which was placed the figure of a sphere and cylinder. 'This,' said I to the Syracusan nobles who were with me, 'this must, I think, be what I am seeking.' Several persons were immediately employed to clear away the weeds and lay open the spot. As soon as a passage was opened, we drew near, and found on the opposite base the inscription, with nearly half the latter part of the verses worn away. Thus would this most famous, and formerly most learned, city of Greece have remained a stranger to the tomb of one of its most ingenious citizens, had it not been discovered by a man of Arpinum."

Several works of this celebrated mathematician have escaped the wreck of time. In abstract geometry we have a treatise on the Sphere and Cylinder, another on the Dimension of the Circle, or the Proportion between the Diameter and the Circumference; on Obtuse Conoids and Spheroids; on Spiral Lines; and on the Quadrature of the Parabola. Of his mechanics we have a treatise on Equiponderants, or Centres of Gravity; and in hydrostatics, a treatise concerning Bodies floating on Fluids.

The existing works of Archimedes were printed at Basil, in a folio volume, Greek and Latin, in 1544. This is the *editio princeps*. Another edition was printed at Paris in 1615. The most complete and best is that printed at Oxford in 1792, in a handsome folio volume, superintended by the late Dr Abraham Roberston. There is a French translation by M. Peyrard, of the works of Archimedes: it was published in 1808, in 2 vols. 8vo.

ARCHIPELAGO, in *Geography*, a general term signifying a sea interrupted with islands; it is however more especially applied to that lying between Europe and Asia, which contains the islands anciently called *Cyclades* and *Sporades*.

ARCHIPRESBYTER, or ARCHPRIEST, a priest established in some dioceses with a superiority over the rest. He was anciently chosen out of the college of presbyters at the pleasure of the bishop.

ARCHISYNAGOGUS, the chief of the synagogue, the title of an officer among the Jews, who presided in their synagogues and assemblies. The number of these officers was not fixed, nor the same in all places, there being 70 in some, and in others only one.

ARCHITECT (Latin *Architectus*, Greek Αρχιτεκτων, from the primitive words αρχη, the *beginning, origin*, or *cause*, and τευχω, to *contrive, construct, build*), an originator, a contriver of structures; one who designs and executes works of architecture. An architect is either civil, naval, or military. To a civil architect the term is applied simply, without the qualifying adjective, and to the others with the distinctive adjective prefixed. Architecture requires of its professor that he be both a man of science and an artist. He has to study it as a useful science and as a decorative art; the former requiring a more than ordinary knowledge of all that natural philosophy teaches, together with a technical acquaintance with the mechanical arts used in building; and the latter a fine perception of what is competent to produce pleasing effects, and in what manner they may be combined to produce grandeur and beauty. It often happens, and particularly on the Continent, where indeed they do not generally profess to be otherwise, that architects are totally devoid of all technical knowledge of the details of their profession, in which case a surveyor or supervisor is required to carry the architect's designs into execution. Such architects are little better than mere draughtsmen. In this country there is a large class of persons called surveyors, most of whom are in fact mere measurers. They too assume the office and distinction of architects, and are frequently employed as such. Country builders, again, who are for the most part simply carpenters, masons, or plasterers, are not unfrequently allowed to execute their own designs, the result of which passes with the vulgar for architecture, and their authors are also called architects. Vitruvius, who, whatever may be his merits as an historian of architecture, certainly well understood what an architect should be, requires him to be versed in almost every branch of science and art that was taught at the time he wrote.

Very few names of the architects of antiquity most deserving of celebrity have descended to us through authentic channels. Vitruvius was himself so obscure as not to be mentioned, or in any way referred to, by any ancient author whose works remain to the present time. Of the authors of the splendid architectural monuments of Egypt and India we know absolutely nothing. It is indeed but with difficulty and uncertainty that we can indicate the architects of the middle ages, the inventors and perfecters of that magnificent and beautiful style which, in the absence of a better generic name, has been called Gothic. They were mostly ecclesiastics,—frequently bishops and abbots.

When learning began to extend itself beyond the cloister, and science and the liberal arts were allowed to shed their influence on the minds of men, their application to useful and agreeable purposes became the occupation or profession of distinct classes. These had of course to derive reasonable emolument from their respective professions, and it was generally made in the shape of fees. Fees, however, could not be well determined in some professions, and among them in that of architecture. At first the architect was paid so much for a design, and a salary as supervisor or surveyor of its execution; but the established custom in this country now is, that the architect shall be paid a commission of five per cent. on the cost of the structure he is engaged to design and execute. For this he makes the design; an estimate of the expense, if required; a specification of every thing required to be done by the builder by contract or otherwise; with working drawings, and drawings of details. He superintends the execution of the structure, and measures and values the whole of the work if necessary, when completed, to check the builder's accounts.

ARCHITECTURE.

History.

THE term Architecture is derived from the name of its professor, *Architect.* It is the art of contriving and constructing buildings; and the thing produced is by metonomy called by the name of the art which produces it, as the art itself is named from its professor. The word is directly from the Latin *architectura*, irregularly formed from the deponent verb *architector*, which is itself from the Greek substantive αρχιτεκτων, Latinized *architector*, *architecto*, and *architectus;* all of which are used by Latin authors. A more regular but less relevant derivation of the Latin words *architectus* and *architectura* is found in the substitution of the participles of the verb *tego, to cover*, &c. for the derivative of the Greek τευχω, *to build*, &c.

When architecture is spoken of simply, without a qualifying adjective, the designing and building civil and religious edifices, such as palaces, mansions, theatres, churches, courts, bridges, &c. is intended; and it is called civil, to distinguish it from naval and military architecture. Although every description of building may thus have the term applied to it, it is by common consent restricted to such edifices as display symmetrical arrangement in the general design and fitting proportions in its parts, with a certain degree of enrichment effected by means of cornices, blocking courses, architraves, or pillared, columnar, or arcaded arrangements. Architecture may indeed be said to bear the same analogy to building, that literature does to language. A plain brick wall covered in the ordinary way with bricks on their edges is not architectural, because it is poor, rude, and unadorned: it produces no pleasing effect, and is such as a totally uninstructed workman would construct merely to answer the purpose required of it. As man, however, is endowed by nature with a taste for beauty and elegance, mere rugged utility does not delight him; as he becomes civilized, he seeks to embellish whatever he produces, that it may give him positive instead of negative pleasure, by presenting to his sense of vision what his mind may dwell on with complacency; and he is thus disposed to avail himself of the dispositions and decorations which constitute architecture. It may be asked, what standard of beauty there is in this art, on which taste may be formed; though it must be obvious, that, like other children of the imagination, such as poetry and music, no other can be assigned than such compositions and modes of arrangement as by their harmony and simplicity attract the attention of the rudest mind, which is pleased without being conscious why, and of the most learned or practised, which discovers in them those proportions and peculiarities of form which always produce the most pleasing impressions, and appear to be dictated by nature. Painting and sculpture have, to a certain extent, their originals in the external works of nature, so that the most uncultured taste may be gratified, or otherwise, with them, as their works are faithful or unfaithful imitations; music is more artificial, and the taste must be cultivated to judge of and enjoy its higher productions; but architecture is purely conventional, requiring a knowledge of its system, and a mind informed as to the principles on which it depends for beauty, even to its appreciation.[1]

As it is necessary, in erecting a new edifice where an old one has stood, to remove all that was falsely constructed and insecure, if not entirely to clear out the foundations; so it is at this time necessary, in writing a treatise on architecture, to show the false grounds on which the old system is founded, and remove the false impressions which it has generally induced.

The earliest extant author on the subject is Vitruvius, who, being ignorant of any other than his native architecture, which was Roman, and generally derived from the Greek, concocted or adopted a silly fable about the origin of building, and pretends to trace from it the invention of what are called "the orders" by the Greeks; giving, however, to each a separate fable of its own. He professes to give the proportions, arrangements, and disposition of the architectural works of the latter people, and the rules by which they were composed. He describes with considerable minuteness various species of temples and other edifices of both the Grecks and Romans, and endeavours to give reasons for almost every thing connected with them. His account of the advance of man from a state of savage wildness to civilization, the discovery and acquisition of fire, and progress in the art of building, made by the early fathers of the human race, is only surpassed in absurdity by his stories of the invention and proportioning of the various columnar ordinances of which the ancients made use; if we except perhaps the fact, that this crude system has been received and propagated throughout the civilized world ever since the resuscitation of the work, four centuries ago. How could a man, who evidently knew nothing of the early history of the world, of the Celtic monuments, or of the history and architecture of Egypt and the East, be supposed capable of describing the inventions and advances in knowledge of the human race? Nor is this all: How can Vitruvius be received as an authority, when it is found that he does not correctly describe any existing edifice in either Greece or Italy, and that no example of ancient architecture, either Greek or Roman, is in perfect accordance with his laws? This we shall show in its proper place, and proceed now to take a view of the rise, progress, and history of our subject, without reference to the popular system, which is based on such fallacious ground.

Origin and history of architecture.

Although it is very probable that men built houses to shelter themselves from the inclemencies of the weather before they constructed temples to the divinity, yet it must be obvious to all who have studied the early history of the human race in connection with its antiquities, and have considered the analogies afforded by the rude and simple nations of the world at the present time, and particularly by those who occupied the western side of the Americas on the discovery of those continents, that though the art of building may have originated in the personal wants of man, the science of architecture was the result of his devotional feelings and tendencies. In Egypt and in India, in Greece and in Italy, in Gaul and in Britain, in Mexico and in Peru, structures connected with the worship of the divinity existed, and still exist, of the earliest date, or rather of dates beyond the range of positive chronological information; some evincing a greater and others a less advance in taste and refinement, but all retaining some analogy, bearing upon the same point, and tending to what may be called architectural arrangement.

[1] Count Algarotti, speaking of the absence of any thing in nature on which architecture may be modelled, says, "with good reason it may be said to hold the same place among the arts, that metaphysics does among the sciences." (*Opere del* Conte Algarotti, edizione novissima, tomo iii. p. 25.)

None of those countries, however, nor any other with which we are acquainted, present any thing intended for the personal accommodation of man in the early ages; nor is there any thing in the sacred structures that could for a moment induce the idea, that the dispositions of architecture arose in the construction and composition of domestic buildings. Every thing rather leads to the belief that devotion and superstition were the originators, carriers on, and, it may be almost said, perfecters of the science.

The modern tent and marquee may be assumed as the representatives of the earliest habitations of man; at first perhaps covered with leaves, then with the bark of trees, and, in a more advanced state, with the skins of animals. It would not be till men began to congregate in towns and cities for mutual defence from the aggressions of each other, that any thing more permanent than such tent-like habitations would be thought necessary, or even convenient, as most of the tribes, if not all, were nomadic. In what manner the cities were fortified, whether by being surrounded with brick walls, or with defences of earth or mud, as the forts in India are at the present day, is not for us here to inquire; but we have no reason to suppose that the houses within them were better than the hovels of the inhabitants of such places in the East now, if they were indeed so good. The rude New Zealanders are found to fortify their villages very respectably, although their habitations are mere huts; and the ancient Mexicans and Peruvians are reported by their discoverers and conquerors to have made their towns or cities very secure by means of walls and other defences, and to have had considerable structures dedicated to the divinity, while their houses were of a mean and unpretending description. It is probable that timber was principally used in the ruder ages by men in the construction of their permanent habitations, for such is the material employed by the South Sea islanders to whom we have referred; and more particularly by the simpler and less savage tribes inhabiting the Friendly and Society Islands of the same hemisphere, who, moreover, thatch their houses with the large leaves of the cocoa-nut and bread-fruit trees. This supposition is supported, too, by the general tenor of the Mosaic history, and by the command which the Israelites received to burn with fire cities whose inhabitants were given to idolatry, which would not have been an efficient mode of destruction if such materials had been employed in building them as were then used in temples; for similar commands enjoined them to "overthrow their altars and break their pillars." Deut. chap. xii. and xiii. Jericho, also, and Hazor, were *burnt* by Joshua. Even so late as the establishment of the kingdom of Israel in the person of David, that monarch is represented to have built himself "a house of cedar." There is indeed no reason whatever for supposing that the dispositions of architecture were employed for domestic purposes till a comparatively late period; and at no time in the history of the human race has the science been rendered so subservient to the comfort and convenience of man in civilized communities, as it is at the present day. To that fact the remains of Herculaneum and Pompeii, for their age, give the most decisive and satisfactory evidence; and since their time the fact will not be disputed.

If what we understand by the term architecture did not originate in, or grow out of, the mode of building which men employed in the construction of their own habitations, our next object must be to discover, whether it can be deduced from the mode they adopted in arranging and constructing edifices for the worship of the divinity.

The earliest intelligible record in existence makes frequent mention of the building of altars, but without temples. The first act of Noah on coming out of the ark, was to build an altar; Abraham built altars at various times and in various places; Isaac and Jacob built altars, and the latter is the first said to have set up a stone under the circumstances detailed in the 28th chapter of Genesis. On awaking after his remarkable dream, he said, "Surely the Lord is in this place"—"this is none other but the house of God"—he "took the stone that he had put for his pillows, and set it up for a pillar, and poured oil upon the top of it, and he called the name of that place Bethel;" and then dedicating it to the Deity, he said, "and this stone which I have set for a pillar shall be God's house." Jacob set up a stone again on which to ratify his agreement with Laban in the most sacred manner. In many other parts of the Old Testament, stones, or pillars as they are called in some places, were set up as witnesses and memorials of sacred engagements. In the covenant at Shechem (Josh. xxiv. 26, *et seq.*), Joshua "took a stone and set it up there under an oak that was by the sanctuary of the Lord. And Joshua said unto all the people, Behold, this stone shall be a witness unto us, for it hath heard all the words of the Lord." After the battle with the Philistines at Mizpeh, in which the Israelites were conquerors, Samuel, who had prayed for their success, "took a stone and set it up between Mizpeh and Shen, and called the name of it Eben-ezer, saying, Hitherto hath the Lord helped us." 1 Sam. vii. 12. The analogy between these stones and the cromlechs of the ancient Celtic nations is too clear not to be observed. "It is remarkable," says General Vallancey, in his *Collectanea de Rebus Hibernicis*, "that all the ancient altars found in Ireland, and now distinguished by the name of cromlechs, or sloping stones, were originally called Bothal, or the House of God; and they seem to be of the same species as those mentioned in the book of Genesis, called by the Hebrews Bethel, which has the same signification as the Irish Bothal."[1] Of these cromlechs there are three kinds, the single upright stone or pillar; the same, with another stone laid on it crosswise; and two upright stones with a third placed on them, like an entablature on two columns; and this third kind, to distinguish it from the other two, has been called by the Greek descriptive name *trilithon*. It is evident, moreover, from the sacred text, that it was customary to offer sacrifices by these pillars or cromlechs; for on the return of the ark from Philistia (1 Sam. vi. 14, 15), the kine drew the cart on which it was placed into a field "where there was a great stone; and they (the people) clave the wood of the cart for a burnt-offering to the Lord," having placed the ark and its contents on the stone. Now the sacrificial stone or altar at Stonehenge is immediately before the great trilithon which forms the end of the hypœthral temple within the external peribolus, and that temple itself is doubtless of the same species as those which Moses built at Mount Sinai, and directed the people to construct on their arrival in the promised land (Exod. xxiv. 4, and Deut. xxvii. 2–6), which they afterwards did under the command of Joshua, the stones or cromlechs being multiplied for special purposes. Moses and Joshua set up twelve stones (probably trilithons), because of the number of the tribes: at Stonehenge there were five. Strabo, speaking of the temples of the Egyptians, describes the most ancient as being of vast extent, but of rude workmanship, without elegance, without grace, and without embellishment of any sort. What could this have been

Pl. I.V.

[1] *Coll. de Reb. Hib.* tom. ii. p. 211.

History.

but the same simple combination of sacred stones which, we have found, was the earliest species of temple on record, and one of which we may presume to be the earliest, in manner if not in date, in existence? Indeed, late travellers have discovered, at Amada in Nubia, about half-way between the first and second cataracts of the Nile, a temple which consists of square piers supporting plain squared blocks of stone, which form a simple entablature, occupying the mid-distance between the ruder Celtic structure and the finished Egyptian columnar arrangement. The Egyptians had made considerable advances on the rude model to which the Greek geographer refers, when the Israelites escaped from them, having already fallen into polytheism and idolatry; and changes in faith inducing changes in form, their temples might no longer retain their monotheistic simplicity, but must be arranged with more complexity to suit the purposes of a complex religion. Lucian and Herodotus both say that the most ancient of the Egyptian temples had had no statues or images in them; but the express command given to the Israelites by Moses, in the passage just referred to in Deuteronomy, that the stones to be set up, and the altar to be made, should be of whole stones, and that no iron tool should be used upon them, warrants the supposition that it was to prevent them from doing what their late masters were then accustomed to do—carve the altar and piers or pillars with images, and so fall into idolatry; and may be admitted as a proof that the Egyptians had already made the advances in architecture which we have presumed: indeed we shall find that they had actually arrived at the splendid results which the ancient capital of Egypt even at this day presents. One of the colleagues of Denon, in a dissertation on the antiquity of Thebes, in the great work of the French Institute on the Antiquities of Egypt, says, "Let us add to all these considerations (that all the historians and philosophers of Greece and Rome agree in assigning the highest antiquity to the Egyptians) that most of the edifices of Thebes bear incontestable marks of great age. This is a fact not of a nature to produce a strong impression on those who have not seen the monuments themselves, but it helps to carry conviction to the minds of those who have been able, in the places where they exist, to compare the edifices of ancient Egypt with each other."[1] He goes on to speak of the causes of their preservation, and concludes with this passage:—"It may be remarked, moreover, that most of the ancient edifices of Thebes are composed of the ruins of other monuments which had perhaps themselves become ruined by age."

But Strabo and Herodotus agree in saying that the Indian caverns or excavations were justly presumed to be more ancient than the temples of Egypt; and a learned modern antiquary (the Rev. Mr Maurice) asserts that they were made by the Celtæ. Now the architectural arrangement of these excavations, and of Hindoo architecture generally, very much resembles the early Egyptian style. This coincidence strengthens the supposition that they had a common origin, and that indeed the science of architecture had its birth in the simple combinations which we see in what are called the Celtic or Druidical remains; and it is not doubted that they originated in devotional feelings.

In assuming Stonehenge to be the oldest architectural monument (in manner, it may be, rather than in the date of its execution), we do not pretend to lower the antiquity of any other, but to put this beyond them all; believing it to be a specimen of primeval columnar architecture, which led the way, as one of the numerous gradations, some of which may have left no traces on the face of the earth, from the monolithic cromlech to the Parthenon of Athens, the Pantheon of Rome, and the Minster of York. It is not a sufficient argument against this assumption, that such structures are not found existing in the East at the present time; for they were doubtless swept away to make room for more ornate edifices, as the custom was, in the same sacred places, and to furnish materials for them; as the latter have in many cases been as completely obliterated from the face of the earth, with the cities to which they belonged. A specimen of the next step in advance exists in the temple at Amada; and, as we shall have occasion to show, it clearly demonstrates the truth of our position, by some of its square piers having been sculptured into cylinders, which exhibit the simplest form of the Greek Doric column.

This, however, is not the generally received opinion. It is thought that the trunks of trees used in the construction of human habitations first suggested the idea of columns; and that the lintels, transverse beams, wall-plates, and rafters, first furnished that of an entablature. Neither authentic history nor analogy appear to us to bear this out; for the most ancient architectural remains, in various places, accord less with the arrangements consequent on such an origin than those which are more modern; and it requires a great stretch of fancy to imagine the derivation of the Titanic structures of Thebes, Pæstum, and Selinus, from the posts of a woodman's hut. But the inquiry, being more curious than instructive, is not worth pursuing further; for indeed no useful result could arise from its determination.

Such being the case, we now proceed to trace the progress of the science from its earliest regular formations, of which we have sufficient and authentic information, down to the present day.

Indian chronology being so vague and undefined, and the connection of the Hindoos with the civilized nations about the Mediterranean Sea having been so much restricted in the earlier ages that we can get little assistance from the Greek historians on the subject, the date of their architectural monuments can be determined only by analogy. That, however, is an uncertain guide, especially in the circumstances in which we are placed, without proper delineations, and indeed without any work that gives a competent idea of them. Though we have held India so long, and by a so much more honourable tenure than the French did Egypt, if we were now to be dispossessed we should leave nothing, and we should certainly retain nothing, to show to our credit that we had ever held it. Such an undertaking as the great work of the French Institute on the Architectural Antiquities of Egypt is far beyond the means of individuals; the constitution of our government appears to preclude the application of funds from the public purse to such purposes; and the East India Company, from whom perhaps something of the kind on the archæology of India might have been expected, have, it would appear, occupations of more interest to them than the advancement of science and art. It may be generally stated, that, in its leading forms and more obvious features, Hindoo architecture strongly resembles Egyptian, and may be considered as of the same family with it.

No nation that ever existed within the annals of the human race has left structures that, in extent, magnificence, and grandeur, can vie with those of ancient Egypt. We have the authority of historians for believing that

[1] *Description de l Egypte*, tome i. p. 432.

there were others in the same country which no longer exist, that must have surpassed those which do remain; and they speak also of the cities of Assyria, as unparalleled in the extent and splendour of their edifices, whose sites, even, are not now determinable. The pyramids, however, mausoleums of a nation—and the temples, monuments of human folly—speak more strongly than any historian can, and compel our belief of what they have been by what they are; whereas the others do not exist but in name. Nineveh and Babylon were—but Thebes and Memphis still remain. It is strange, indeed, that a people who displayed such energies in the construction of tombs, pyramids, and temples, should have left no work of any description that could be applied to any really useful purpose. Denon, speaking of Thebes, says, "Still temples—nothing but temples—not a vestige of the hundred gates, so celebrated in history; no walls, quays, bridges, baths, or theatres; not a single edifice of public utility or convenience. Notwithstanding all the pains I took in the research, I could find nothing but temples, walls covered with obscure emblems, and hieroglyphics which attested the ascendency of the priesthood, who still seemed to reign over the mighty ruins, and whose empire constantly haunted my imagination."[1] Champollion, however, in his late researches, speaks of the remains of quays, and calls some of the structures palaces instead of temples; but as the former exist only in connection with the latter, they can hardly be considered as any thing more than mere embankments; and the regal and hierarchical offices having been so closely connected in the economy of ancient Egypt, it is of little or no consequence to our position whether the same edifices be called palaces or temples. Diodorus Siculus says, in one place, that "Busiris," believed to be one of the Pharaohs who persecuted Israel, "built that great city which the Egyptians call Heliopolis and the Greeks Thebes, and adorned it with stately public buildings and magnificent temples, with rich revenues;" and that "he built all the private houses, some four, and others five stories high."[2] Shortly after, speaking of Memphis, to account for the splendour with which the Egyptians built their tombs, and the comparative meanness of their houses, the same author says, "They call the houses of the living inns, because they stay in them but a little while; but the sepulchres of the dead they call everlasting habitations, because they abide in the grave to infinite generations. Therefore they are not very curious in the building of their houses; but in beautifying their sepulchres they leave nothing undone that can be thought of." Strabo also speaks of a splendid dwelling which was erected for the priests at Heliopolis, but that probably was one of the sacred palaces just referred to; for none of the ancient writers describe the domestic structures of the Egyptians, from personal knowledge of them, as being worthy of any notice; and that assertion of Strabo is too loose and unsupported by contemporary authority or analogy to deserve confidence of itself. To the statement of Diodorus, that private houses were built to four and five stories high, we can give no credence whatever; for the construction of edifices in tiers or stories was very imperfectly understood even in his time, which was many centuries after the destruction even of Thebes; and none of the existing remains of that city give the slightest indication of a second story, or indeed of aptitude to construct one, except the rude landings in some of the propylæa. Herodotus says that the Egyptians were the first who erected altars, shrines, and temples; but of their private houses he says nothing; neither does he describe any of the temples as they existed in his time in Egypt; so that he in fact affords no assistance in determining the comparative antiquity of the various architectural structures which remain to the present time in that country. Indeed the ancient historians and topographers speak for the most part so wildly of dates and dimensions, that they are, at the best, most unsatisfactory, if not fallacious, guides; and in the present case, that of Egypt, the style of architecture is so uniform, or so imperfectly understood, that no argument can with safety be drawn from it, as there may in other cases. In Hamilton's *Ægyptiaca*, the author says, with reference to this question: "In Egyptian architecture there is an uniformity of structure, both in the ornaments and in the masses, which, if unassisted by other circumstances, reduces us to mere conjecture; and that not only for the difference of a century or two, but perhaps for a thousand years."[3] Again: "The monuments of antiquity in Upper Egypt present a very uniform appearance; and his first impressions incline the traveller to attribute them to the same or nearly the same epoch. The plans and dispositions of the temples bear throughout a great resemblance to one another. The same character of hieroglyphics, the same forms of the divinity, bearing the same symbols and worshipped in the same manner, are sculptured on their walls from Hermopolis to Philæ. They are built of the same species of stone; very little difference is discernible in the degrees of excellence of workmanship, or the quality of the materials; and where human force has not been evidently employed to destroy the buildings, they are all in the same state of preservation or decay."[4] But we are fortunately now about to be rid of that difficulty by the erudition and industry of those learned men who have given their attention to the hieroglyphic literature of the Egyptians. M. Champollion professes to have determined the date of every monument of antiquity in that country which is inscribed, by the inscriptions, which he has qualified himself to read. As yet, however, we are not in possession of the whole result of his discoveries.

Hypogea, spea, or caves formed by excavation, are found of earlier date than any existing structures. Internally they present square piers, which were left to support the superincumbent mass of mountain or rock when their magnitude rendered it necessary. These were originally tombs; and the cave of Machpelah, of which Abraham made the purchase as a burying-place for his family, was, doubtless, one of that kind. Oratories or chapels were afterwards made in the same manner, but, it would appear, not until columnar architecture had come into use; for their entrances are generally sculptured into the resemblance of the front of a rude portico, or an actual portico or pronaos is constructed before them. Many such are found on the banks of the Nile, in its course through Nubia and Egypt. At Ibrim, which the Greeks call Primis, in the former country, there are several of these cavern temples, the earliest of which, according to M. Champollion, bears date of the reign of one of the Pharaohs, who was contemporaneous with Abraham, or his son Isaac, or about eighteen centuries before Christ; the latest is of the time of Rhameses Sethos, the Sesostris of Greek history. To some of the cavern tombs and temples in Upper Egypt M. Champollion accords even a still higher degree of antiquity. The earliest columnar structures which are found within the same range of country do not appear to bear a higher date than that of the

[1] *Voyage dans la Basse et la Haute Egypte*, p. 176. Par V. Denon.
[2] Diod. Sic. lib. i. cap. iv.
[3] *Ægyptiaca*, by Wm. Hamilton, Esq. F. S. A. Part I. p. 280.
[4] Ibid. p. 18.

History. earliest kings or Pharaohs of the eighteenth dynasty of Manetho, which began about the time of the Jewish patriarch Abraham, and ended with the Pharaoh from whom his descendants escaped under the conduct of Moses. The temple at Amada, to which we have already referred, is of the time of Moeris, who was contemporary with the patriarch Jacob, and consists of twelve square piers or pillars, and four columns, which possess the form and character of the Greek Doric, and may, it is suggested, be called *protodoric*. The same intention, if it may be so called, is found in others of the early monuments, but in none so perfect as in this, as almost all the structures of ancient Egypt were either destroyed or seriously damaged by the Persians at the time of their invasion under Cambyses; and they are supposed not to have ascended the Nile much above Psalcis or Dakkè, but to have turned off by the way across the desert to Ethiopia, so that the temple at Amada, which is considerably above Dakkè, escaped.

Of all the Pharaohs, Sesostris, the first of the nineteenth dynasty, was the most distinguished for the great and extensive works he executed in architecture. Most of the existing ruins in Egypt, anterior to the Persian invasion, are attributed to that monarch by M. Champollion. The immense ruins at Thebes, which have been by turns called the Memnonium and the tomb of Osymandyas, and are popularly called Medinet Abou, are proved by that gentleman to be those of the Palatial Temple of Rhameses the Great, or Sesostris, and which he therefore calls the Rhamesseion, the ruins at Luxor being those of the Memnonium; that edifice or series of edifices having been constructed by Amenophis Memnon, of the eighteenth dynasty, one of the good and beneficent princes by whom the children of Israel were protected during their sojourn in Egypt. The magnificent structure at the village of Carnack, within the same city, appears however to excel all the rest in extent and grandeur, and is at least their equal in antiquity. It is generally known as the temple of Carnack, but it has been distinguished as that of Jupiter Ammon. It bears inscribed the name of Thothmosis II., the predecessor of Amenophis Memnon. From the existing remains of Thebes, and the relations of historians combined, that city may be assumed to have attained its highest degree of splendour in the time of Sesostris; few of the ruins it presents being of later date than the time of that monarch. This being admitted, and we believe it can hardly be denied, it must be admitted also that the science of architecture, and the practice of the mechanical arts, were already well understood; for the composition of the monuments displays an exquisite combination of simplicity and harmony, which produce the finest effects of beauty and grandeur; while their construction is the apparent result of perfection in the use of mechanical powers. All the Pharaonic monuments, indeed, throughout Egypt and Nubia, are wonders of science and art. The structures of Ombos, Apollinopolis Magna, and Latopolis, between Thebes and the cataract, M. Champollion determines to be generally of the age of the Ptolemies, and some even of the Roman dominion; all, however, of these of comparatively modern date are evidently restorations; others, probably of the earliest ages, having occupied the same sites. Indeed M. Champollion asserts generally that the Ptolemies, and the Ethiopian Ergamenes himself, only rebuilt temples where they had already stood in the times of the Pharaohs, and to the same divinities that had always been worshipped there. He goes on to say, that the religious system of this people was such a complete whole, so connected in all its parts, and fixed from time immemorial in so absolute and precise a manner, that the dominion of the Greeks and of the Romans did not produce any innovation; the Ptolemies and the Cæsars only restored in Nubia what the Persians had destroyed, and rebuilt temples where they had formerly stood, and dedicated them to the same gods.

Of the arrangements of an Egyptian temple we shall speak when we come to treat of Egyptian architecture as a style. In construction the Egyptians appear to have used wrought stones at a very early period: this probably was induced by the still earlier habit of excavating rocks to form tombs; for the walls in their oldest structures are composed of rectangularly cut blocks in parallel courses; whereas we shall find that the most ancient specimens of walling in Greece and Italy are not so. In the Pharaonic monuments, besides walls built in parallel courses of wrought stone, we find squared piers also; and frequently, in the same structure with them, the peculiarly formed tumescent column with a bulbous capital or head, covered with an abacus or square tablet, corresponding with the size of the piers, and warranting the supposition that that species of column is a mere refinement on the simple square pillar. What dictated its singular form must remain matter of speculation. The cylindrical column with a bell-shaped capital was the next advance, and that also is found in the same structures, though not in the simplest and earliest of them, in which piers occur. Terminal or Caryatic figures are common in those early works also; not absolutely supporting an entablature, but placed before piers which do, and having the appearance of doing it themselves when seen in front. Bold, massive, rectangular architraves extend from pier to pier and from column to column, and are generally surmounted externally by a deep coved coping, or cornice, with a large corded and torus-formed moulding intervening. This masks the ends of the stones which are placed transversely on the architraves to form the ceiling internally, the whole being flushed square on the top, and forming a flat terrace or floor. The pyramidal form of the moles or propylæa, peculiar to Egyptian temples, may have been suggested by the pyramids, as neither that form nor those adjuncts to a temple appear to have been used before the period at which it is supposed the former were constructed. The grandeur and dignity inherent to that form would indeed hardly be suspected till its appearance in the pyramids themselves; and certainly the impression of its effect must have been strong, to induce men to seek it in a truncated pyramid under a very acute angle, as in the propylæa, relying on the tendency of its outline alone. It was gradually, too, that this tendency was generally applied, for in the earliest Pharaonic structures the vertical outline is most common, except in the propylæa, where they exist; and in the structures of the Ptolemies the inclined outline pervades every thing. The monolithic obelisk is of Egyptian origin also. Its tapering form may be the consequence of the impression the pyramidal tendency had occasioned, though perhaps the object itself is the representative of the single stone by which religious feeling appears first to have expressed itself. Obelisks were set up by the Egyptians, sometimes in the courts or atria of their temples, and sometimes before the entrances to them.

Of all the architectural works of the Egyptians, however, none have excited so much the wonder and curiosity of men as the pyramids themselves; not in consequence of any particular beauty in their composition, or ingenuity in their construction, but simply because of their immense magnitude, and unknown use, and antiquity. Denon makes the following observation on his first visit to the great pyramid of Gizeh, at Memphis. "If we reflect upon these pyramids, we shall be inclined to think the pride that constructed them greater even than these masses them-

selves, and shall scarcely know whether to reprobate most the insolent tyranny which commanded, or the stupid servility of the people which executed, the undertaking. None but sacerdotal despots would ever have undertaken them, and none but a stupid fanatical people would ever have built them....The most honourable reason that can be assigned for their erection is the emulation of man to excel the works of nature in immensity and duration, and in this project he has not been altogether unsuccessful. The mountains near the pyramids are not so high, and have suffered more from time than the pyramids themselves."[1] But Memphis itself was of late foundation in comparison with other cities on the Nile. According to Professor Heeren,[2] civilization descended by the Nile from Ethiopia with the caste of priests who brought with them the worship of Ammon, Osiris, and Phtha (the Jupiter, Bacchus, and Vulcan of the Greeks), and "the spread of this worship, which was always connected with temples, affords the most evident vestiges of the spread of the caste itself; and those vestiges, combined with the records of the Egyptians, lead us to the conclusion that this caste was a tribe which migrated from the south, above Meroe, in Ethiopia, and, by the establishment of inland colonies around the temples founded by them, gradually extended and made the worship of their gods the dominant religion in Egypt. Proofs of the accuracy of this theory," he asserts, "may be deduced from monuments and express testimonies concerning the origin of Thebes and Ammon from Meroe; that it might indeed have been inferred from the preservation of the worship of Ammon in this last place." The same author goes on to say, that "Thebes was, if not the most, one of the most, ancient cities of Egypt;" and that "Memphis and other cities of the vale of the Nile are known to have been founded from Thebes." Now Thebes exists to the present time in the ruins of her magnificent temples, the works of the Pharaohs, but without the vestige of a pyramid, so that it may be concluded that none was ever built there; and Memphis may be said to exist in the everlasting pyramids of Gizeh and Saccharah, which occupy two of its extremities; but no indication remains of the existence of a temple of any kind: indeed the exact site of the city cannot be determined except by the pyramids. Herodotus, however, speaks of temples at Memphis, particularly of that of Vulcan or Phtha; but certainly no vestige of such has existed for a long period of time within that vicinity. Memphis was a great and ancient capital, and why should it not retain some evidence of the existence of temples in it? But Thebes was a greater and more ancient capital, and indeed the metropolis of all Egypt; and why has it no pyramids? These things are equally unaccountable and inexplicable, affording groundwork for almost any theory, but giving perfect support to none. Mr Hamilton, in his *Ægyptiaca*, before quoted, places Memphis considerably further south, where some ruins have been discovered which may be thought to give a colour to his supposition. But the ruins are of very inconsiderable extent, and are all prostrate, so that nothing can be positively determined by them; and the statement of Pliny as to the relative distances of the Nile and the city from the pyramids of Gizeh being proved to be correct in the one, may be admitted in the other. If Herodotus's account of the building of the pyramids be received, they are of comparatively modern date, the oldest having been constructed several generations after the time of Sesostris, under whom Thebes attained its highest degree of splendour; but this would leave unaccounted for the tendency to pyramidal forms in Egyptian architecture before referred to, unless every example exhibiting that tendency were itself referred to a date posterior to that assigned to Cheops and Cephron, which cannot be done in accordance with the assertions of M. Champollion as to the structures of Thebes, Elephantina, and Nubia generally.

From its immense size, the dimensions of the great pyramid of Gizeh, at Memphis, are variously given by the various persons who have measured it. M. Nouet, who was of the French commission in Egypt, and had perhaps the best opportunity of being correct, determined its base to be a square whose side is 716 French or 768 English feet in length, occupying about the area of the great square of Lincoln's-Inn-Fields in London; and its height 421 French or 452 English feet, or about one third as high again as St Paul's cathedral. It is built in regular courses or layers of stone, which vary in thickness from two to three feet, each receding from the one below it, to the number of 202; though even this is variously stated from that number to 260, as indeed the height is given by various modern travellers at from 444 to 625 feet. And the ancient writers differ as widely, both among themselves and with the moderns. On the top course the area is about 10 English feet square, though it is believed to have been originally two courses higher, which would bring it to the smallest that in regular gradation it could be. It is a solid mass of stone, with the exception of a narrow corridor leading to a small chamber in its centre; and a larger ascending corridor or gallery, from about half the distance of the first to another larger chamber at a considerable distance, vertically above the former, in which there is a single granite sarcophagus, not more than large enough for one body, putting the intention of the structure clearly beyond doubt. The other pyramids differ from that of Cheops (as the largest is called) in size, and slightly in form and mode of construction, some having the angles of the steps or courses of stone worked away to a plain surface, and some not diminishing in a right line. One of the middle-sized pyramids is unlike all the rest, in being neither smooth nor in small steps, but in six large steps or stories, apparently of equal height, and diminishing gradually. But the circumstance which most distinguishes it is, that it is constructed of rude unshapen blocks of stone, cemented together with a very large proportion of mortar. Another is of unburnt brick, and has consequently become ruinous and mis-shapen.

The famous labyrinth, of which Herodotus speaks as having been built by the twelve kings of Egypt, beyond the lake Mœris, is believed by Denon, after examination of the described site, to be little better than fabulous, and that the historian was imposed on by the priests, from whom he derived most of his information. He says, indeed, that he saw and examined it himself; but his description is so vague, that an architect who should endeavour to make a design from it, would be greatly embarrassed. As we can therefore derive no information from it with regard to architecture, it need not be further discussed here. It has been suggested as probable, and indeed the opinion has been maintained, that the pyramids stand over immense substructures; that their areas are occupied by chambers, in which may be found the arcana of Egyptian lore, of which they are the depositories. If it really be so, may not the labyrinths just referred to have been under the pyramid, which the historian says was constructed at the point where the labyrinth terminates, instead of near it? His expression is so ambiguous, that it leaves room for a suggestion of the kind.

Of the domestic architecture of the Egyptians we have

[1] *Voyage dans la Basse et la Haute Egypte*, p. 77. Par V. Denon.

[2] *Manual of Ancient History*, p. 58.

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no knowledge whatever. The statements of the ancient writers on the subject have been already mentioned; but supposing them to be more explicit, and more in conformity with probability, than they really are, without existing remains we could form but a very imperfect idea of what it was. Reasoning from analogy, and the slight information of historians, we should conclude that the habitations of the Egyptians were of a very unpretending description. The already quoted statement of Diodorus Siculus, that "they are not very curious in the building of their houses," even in his time, after their long intercourse with Greece, and their more recent connection with luxurious Rome; added to the fact, that no indications of domestic structures exist in any part of the country, and that the presumed habitations of the priests, in the ancient temples, are small and inconvenient cells; and all these things, taken in conjunction with the mildness of the climate and the salubrity of the atmosphere, we think it must be admitted, warrant the conclusion.

No style of architecture of which we have any knowledge is so well qualified to produce impressive effects on the mind as the Egyptian. The mere assumption of its forms, however, is not sufficient to produce its effects; and drawing is more incompetent to convey an idea of it than perhaps of any thing else in art. To this point the authors of the great work of the French Institute on the antiquities of Egypt bear testimony in strong language. Speaking of the incompetence of drawings to convey just ideas of the grandeur, magnificence, and beauty of the Egyptian temples, and other remains of antiquity, they say, "Despite the care we have given ourselves to describe the Egyptian monuments, we cannot even hope that we have succeeded in giving to others the ideas which we ourselves received from actual views and present contemplation of them; for there are things which drawings and descriptions cannot convey. Geometrical drawings are without doubt quite competent to show the form and proportions of an edifice, its disposition and distribution; but far indeed are they from giving satisfactory ideas of the elegance and effect of structures. Frequently we had to regret how much of the beauty of the original was lost in its geometrical representation on paper; for what in execution was light and graceful, often in the geometrical drawings appeared heavy and inelegant."[1]

The materials used in the construction of the Egyptian architectural monuments are, for the most part, granite, breccia, sandstone, and unburnt brick. The granite was principally supplied by the quarries at Elephantina and Syene, for which the Nile offered a ready mode of conveyance; some species were brought down the river from Ethiopia, but we do not find that the materials were at any time brought from any other foreign country. It may be remarked, too, that in the earliest structures the common *grès* or sandstone is principally employed. Excepting the obelisks and some few of the propylæa, all the temples at Thebes are of that material. In Lower Egypt, on the contrary, and in the works of later date generally, almost every thing is constructed of granite.

Persian, Assyrian, and Phœnician architecture.

Herodotus informs us that the ancient Persians had neither statues, temples, nor altars; and Diodorus Siculus affirms that the palaces of Persepolis and Susa were not built till after the conquest of Egypt by Cambyses, and that they were constructed by architects of that nation. In this case, as in that of India, we are at a great loss for evidence. The Persepolitan remains, though frequently visited and slightly sketched, have not been explored and delineated by such men as Stuart and Revett, or the authors of the great French work we have so often alluded to. That the Persian style, though very different in particulars, does bear a relation to the Egyptian family, however, is very evident. Sir Robert Ker Porter, in his travels in the East, says that the first impression he received in his first walk among the ruins of Persepolis was, that "in mass and in detail they bore a strong resemblance to the architectural taste of Egypt."[2] Nevertheless, there is a strong probability that the Persian is itself an original style, and that the resemblance is merely fortuitous, similar results arising from the same causes, as in Egypt and India; for the eastern parts of that country are believed to have been the earliest seat of the human race. Professor Heeren says of Persia, "it cannot be doubted, that long before the rise of the Persian power, mighty kingdoms existed in these regions, and particularly in the eastern part of Bactria; yet of those kingdoms we have by no means a consistent or chronological history—nothing but a few fragments, probably of dynasties which ruled in Media properly so called, immediately previous to the Persians;"[3] from whom the style of architecture may be derived, though indeed we know of no remains of earlier date than those which are properly called Persian. But we may be said to know nothing of Bactria; it may, and probably does, rival Elora, Salsette, and the banks of the Nile, in primitive specimens of architecture.

We have neither historical nor archæological information that can be depended on to prove what the state or style of architecture was among the ancient Assyrians. Lucian says, however, that their temples were less ancient than those of Egypt. The ruins believed to be those of the great capital of Babylonia present nothing but shapeless masses of brick, from which no idea whatever can be formed as to the style of architecture, or the progress it had made in that country; but some cylindrical and other seals and fragments, in *terra cotta*, lately found by excavation among those ruins, now in the British Museum, are sufficiently in accordance with the rest of the eastern antiquities to be received as evidence of the general assimilation of its style of design with that which was common to the neighbouring nations.

The Phœnicians, we are told by Lucian, built in the Egyptian style; but their country retains no memorials of its ancient architecture by which we might confirm or correct his information. Doubtless Carthage and the other colonies of Phœnicia followed their parent country in this particular.

As far as we can judge from the trifling documents we possess of the architecture of the ancient Mexicans and Peruvians, it was of a rude but massive character, and may be thought also to resemble the early architecture of India, Egypt, and Persia more than we can see any reason for, except in the tendency of the mind of man to the same result when he is placed under similar circumstances. An impression to this effect appears to have been made on Humboldt, who, when speaking of a pyramidal mass of ancient Mexico, says, "It is impossible to read the descriptions which Herodotus and Diodorus Siculus have left us of the temple of Jupiter Belus, without being struck with the resemblance of that Babylonian monument to the *teocallis* of Anahuac."[4]

It is an illustration of the fact that the wants and fancies of man lead him to nearly the same results as he becomes civilized, without communication and consequent imitation, that the plans given by Sir William Chambers, of Chinese public and private buildings, might be taken,

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[1] *Description de l'Egypte*, vol. i. p. 292.
[2] *Travels in Georgia, Persia, &c.* by Sir R. K. Porter, vol. i. p. 579.
[3] *Manual of Ancient History*, p. 26.
[4] Humboldt's *Personal Narrative*, vol. i. p. 82.

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at the first glance, for either Hindoo, Greek, Roman, or Moresco—of course not considering magnitude of parts, but general forms and arrangements. Indeed, the remark may be extended beyond the mere plans; for all have, to a certain extent, insulated columns placed equidistant, and crowned with an entablature; and the general appearance of many Chinese buildings is quite Moorish.

Architecture was not likely to flourish among the shepherd tribes of Israel. It is in agricultural and commercial countries, such as Egypt and Greece, that its noblest works are produced, and not among the nomades of Arabia and Palestine. Saul, the first king of Israel, appears to have had no settled place of abode; and the most sacred ceremonies of the Jewish religion were performed at Gilgal, where was the temple of unhewn stones set up by Joshua on taking possession of the promised land, and making a covenant between God and the people, until the building of the temple at Jerusalem in the place rendered holy by Abraham's great sacrifice. Saul himself was confirmed in the kingdom at Gilgal, and there the nation swore allegiance to him with sacrifices to the Almighty; but as yet nothing existed there in which to perform the rites, but the ancient Celtic structure to which we have alluded. After the division of the tribes into two kingdoms, a splendid temple was erected on the site of Gilgal, in Mount Gerizim, as the national temple of the kingdom of Israel. Like his predecessor on the throne, David appears to have been but indifferently lodged till towards the end of his reign, when he is said to have built himself a house; and until the temple was built in the following reign, the ark of the covenant was never in a fixed place;—it was at one time in a private house, at another in captivity among the Philistines; and, indeed, King David expressed his shame that he had a house of cedar, whilst the ark of the Lord still dwelt in a tent. These things, and the fact that Solomon sent to Tyre for workmen, and indeed for an architect also, are, we think, conclusive evidence, that in whatever state architecture was among the Jews from the building of the temple at Jerusalem, it was very low before that time; and from the descriptions we have of that edifice itself in the Bible, it appears to have exhibited a greater degree of barbaric splendour than of classic elegance. From mere description, however, it is impossible to understand an unknown species of building, as many things we shall have occasion to refer to will clearly prove.

Few things have occasioned controversies more amusing, from the singularity of some assumptions, and the absolute futility of them all, than the style and manner in which Solomon's temple was built. Villalpanda, a Spanish Jesuit, appended to a commentary which he wrote on the prophecies of Ezekiel, a long dissertation on the first and second temples of Jerusalem, in which he insists that the theory and practice of permanent architecture commenced with the building of that temple by Solomon—that with it, "the orders," which, he says, are falsely attributed to the Greeks, came into existence—that indeed the design (from a passage in the first book of the Chronicles), perfect in all its details, was given to David, *drawn by the hand of God!* He moreover pretends to show, that the proportions assigned by Vitruvius to the different orders accord exactly with the descriptions given of the temple of Solomon; and accuses Callimachus of usurping the honour of inventing the Corinthian capital, which could not belong to him, as it was of divine origin, and had been executed in the temple at Jerusalem centuries before he was born. Some learned, and in some respects sensible men, have attempted to support this theory; and others have thought it worth while to controvert it, by proving that the architect and the principal workmen were all either Egyptians or Phœnicians, and that consequently the edifice must have been in the Egyptian style. A learned architect of the present day has endeavoured to show that it was in the Greek style, and that its form, proportions, and distribution, were not dissimilar to those of the temple of Ceres at Eleusis. As the Phœnicians, who were principally employed by Solomon, themselves built in the Egyptian manner, we think the probability is great that it was in the Egyptian or Phœnician style, as far as the Jewish ceremonial would permit; and certainly the descriptions of its distribution accord better with that of an Egyptian than of a Grecian temple. The pillars of Jachim and Boaz, which are said to have been set up before the temple, correspond exactly in relative situation with the obelisks in temples at Thebes. Clemens of Alexandria, too, gives a description of an Egyptian temple very much like that of the Jewish; and the palm-leaves, roses, fruits, and flowers, in the latter, are very common in existing specimens of the former, whereas in the Greek remains of early date no such things are to be found. Whether the Jews in after-times possessed a national style of architecture or not, we cannot tell: there is no reason, however, for supposing that they did; for their monotheistic structure at Jerusalem was not repeated in other places, as the temples of the heathen divinities were among the Greeks and Romans, by which they might have acquired a peculiar mode of composition and combination. The non-existence of a national Jewish style of architecture tends also to strengthen our position, that architecture did not originate in the disposition and decoration of buildings for domestic purposes, of which the Jews must, when settled, have made as much use as other nations; and a multiplicity of religious edifices, in the construction of which they might have acquired one, was forbidden by their code.

Pelasgic architecture.

In various parts of Greece and Italy, specimens of rude walling are found of such remote antiquity that they are, as by common consent, referred to the fabulous ages, and, for want of a more distinctive term, are called Cyclopæan. Now it appears, from the concurring evidence and opinions of most antiquaries, that a people who have been called Pelasgi, or sailors, migrated from Asia Minor, or the coast of Syria, at a very early period, and possessed themselves of various countries, some of which were unoccupied, and others inhabited by Celtic tribes. Mr Godfrey Higgins says that the Pelasgi were Canaanites, and being a hardy sea-faring race, they soon subdued the Celtic inhabitants of Delphi in Greece, or of Cuma in Italy, who, from their first quitting the parent hive, never had occasion for an offensive weapon, except against wild beasts; and that they were the people who settled Carthage, Spain, and Ireland. Bishop Marsh has proved the Pelasgi to be Dorians, Dr Clarke has proved the Etrusci to be Phœnicians, and Gallæus has proved the Dorians to be Phœnicians. Thus, says Mr Higgins, the Pelasgi, the Etrusci, and the Phœnicians, are all proved to be the same. According to Professor Heeren, also, who affixes dates to the various migrations, the Pelasgi were of Asiatic origin. "Their first arrival in the Peloponnesus was under Inachus, about 1800 years B. C.; and according to their own traditions," he says, "they made their first appearance in this quarter as uncultivated savages. They must, however, at an early period, have made some progress towards civilization, since the most ancient states, Argos and Sicyon, owed their origin to them; and to them, perhaps with great probability, are attributed the remains of those most ancient monuments generally termed Cyclopic."[1] He adds, that the Hellenes, a people

[1] *Manual of Ancient History*, p. 119.

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of Asiatic origin also, expelled the Pelasgi from almost every part of Greece, about 300 years after their first occupation of it; the latter keeping their footing only in Arcadia and in the land of Dodona, whilst some of them migrated to Italy, and others to Crete and various islands. The arrival of the Egyptian and Phœnician colonies in Greece, Professor Heeren thinks, was between 1600 and 1400 B. C.

The connection of Greece and Italy with each other, and with Egypt and Phœnicia, is thus made evident. The Cyclopæan structures, however, were the works of the rude Pelasgi before that connection took place, except as far as it existed in their having a common origin. They occupied, either simultaneously or consecutively, both Greece and Italy; and this accounts for the sameness of that peculiar and original mode of structure which, we have said, is found in both countries, though no evidence exists of its ever having been practised elsewhere. If, indeed, the things in question were the work of the earlier Celtic inhabitants, a still more remote date must be assigned them than they could derive from the Pelasgi; and this is the opinion of Mr Higgins, supported, he contends, by the suffrages of Dodwell, Clarke, and others, who say that the doorway called the Gate of the Lions, in the Acropolis of Mycenæ, is built exactly like the remains of Stonehenge. The most ancient specimen of Cyclopic walling is found at Tyrinthus, near Mycenæ. It is composed of huge masses of rock roughly hewn and piled up together, with the interstices at the angles filled up by small stones, but without mortar or cement of any kind. The next species is in stones of various sizes also, shaped polygonally, and fitted with nicety one to another, but not laid in courses. Specimens of this are found at Iulis and Delphi, as well as at the places already mentioned, in Greece, and in various parts of Italy, particularly at Cossa, a town of the Volsci. This also was constructed without mortar. The mode of building walls, which took the place of that, is not called Cyclopæan; it is in parallel courses of rectangular stones, of unequal size, but of the same height. This is common in the Phocian cities, and in some parts of Bœotia and Argolis. To that succeeded the mode most common in, and which was chiefly confined to, Attica. It consists of horizontal courses of masonry, not always of the same height, but composed of rectangular stones.

Grecian architecture.

The oldest existing structure in Greece of regular form is of far superior construction to the Cyclopæan walling, and must be referred to the Egyptian or Phœnician colonists. It is at Mycenæ, and consists of two subterranean chambers, one of which is much larger than the other. The outer and larger one is of circular form, and is entered by a huge doorway at the end of a long avenue of colossal walls, built in nearly parallel courses of rectangular stones, roughly hewn, however, and laid without mortar. Its external effect is that of an excavation, though the structure of the front is evident; and internally it assumes the form of an immense lime-kiln; its vertical section being of a somewhat conical form, under nearly parabolic curves, like a pointed, or what is vulgarly called a Gothic arch. The construction of this edifice was thought to afford clear evidence that the Greeks were acquainted with the properties of the arch; but in the most material point this was destroyed on finding that it consisted of parallel projecting courses of stone in horizontal layers, in the manner called by our workmen battering, or more correctly perhaps corbelling. It proves, however, that its architect understood the principle of the arch in its horizontal position; for Mr Cockerell has discovered, by excavations above it, that the diminishing rings of which the dome is composed are complete in themselves for withstanding outward pressure; the joints of the stones being partly wrought concentric, and partly rendered so by wedges of small stones driven tightly into them behind. The apex is formed, not by a key-stone, for the construction does not admit of such, but by a covering stone, which is merely laid on the course immediately below it. It may be added, that internally the lower projecting angles of the stones are worked off to follow the general outline. Though this is the largest and most perfect, its internal diameter at the base being 48 feet 6 inches, and its height from the floor to the covering stone 45 feet, yet edifices exhibiting similar structure are found in many other places in Greece itself, in Egypt, in Sicily, and in Italy. They all however tend to prove, that the principle of the construction of the vertical arch was unknown at the time of their erection in all those countries; and their erection is as evidently of the most remote antiquity, perhaps of the presumed era of Dædalus, to whom some have assigned many of them, as well as the discovery of so much of the principle of the arch as is exhibited in the arrangement of the horizontal rings or layers in the Mycenæan monument. Neither could the mechanical powers have been unknown to their constructors. In the edifice which we have described, and which is thought by some to be the Treasury of Atreus, or the Tomb of his son Agamemnon, mentioned by Pausanias as existing among the ruins of Mycenæ in his time, the inner lintel of the doorway is 27 feet in length, 16 feet deep, and nearly 4 feet thick, weighing, it is computed, upwards of 130 tons; and the lintel of the Gate of the Lions in the Acropolis of the same city, is, from its immense magnitude, also strongly illustrative of the great mechanical skill of the people of those times. As the treasury of Atreus at present exists, it exhibits nothing like an attempt at decoration, except that the doorway is, on the outside, sunk in two faces all round, as if to harmonize with some architectural composition; and the interior of the edifice may be supposed to have been lined, probably with plates of metal, like the tower of Acrisius, as bronze nails for attaching them to the vault still remain. Some sculptured fragments of marble which have been found among the ruins of the fallen parts and the rubbish which chokes up the entrance, together with indications on the external front of the edifice that it was cased, have led to an ingenious attempt at restoration, upon the supposition that the fragments were parts of a frontispiece. The fact that such frontispieces were sometimes carved, and sometimes constructed, in connection with the entrances of excavated tombs and other *spea* in Egypt and Nubia, gives a degree of probability to the idea that it would not otherwise have; for the fragments do not resemble the earliest existing specimens of Greek architectural forms; though indeed these latter may be traced to Persepolis, and Ibrim in Nubia, according to several ingenious antiquaries and architects. In curious accordance with this Mycenæan structure is the ancient monument at New Grange, near Drogheda, in Ireland. Ruder in every respect than the former, in form, construction, and mode of access, it bears such a striking similarity to it, that it is almost impossible to be supposed the effect of mere chance. The opinion of Mr Godfrey Higgins, that the Pelasgi, who peopled many of the countries on the shores of the Mediterranean Sea, peopled Ireland also, appears to be supported by this coincidence between the so-called Treasury of Atreus, or Tomb of Agamemnon, in the Peloponnesus, and the monument at New Grange in Ireland.

We know of no columnar edifice in Greece, or elsewhere in the Grecian style, of earlier date than the ruined temple at Corinth, which is in the plainest and sim-

plest form of what has been called the Doric Order, though it would be more correctly designated the Doric Style; for the term Order is objectionable, because it supposes rules and limitations to what in its best times was subjected to neither. As, however, it is the term best understood, we shall not hesitate to continue it. It is difficult, if not impossible, to ascertain where and in what manner the Doric order originated. The example we have referred to, though the earliest, does not differ in its leading features and characteristics from the more perfect specimens of later date; and it bears no direct and easy analogy to any species of columnar arrangement of other countries and earlier times. The story of Vitruvius, even supposing it rational, does not coincide with the Greek style of Doric at all, but, if with any thing, with the Roman examples of it, which at the best are mean and inelegant deteriorations of the simple and beautiful original. This author says that "Dorus, the son of Hellenus and of the nymph Orseis, king of Achaia and of all the Peloponnesus, having formerly built a temple to Juno in the ancient city of Argos, this temple was found by chance to be in that manner which we call Doric."[1] In another place he deduces the arrangements of this same order from those of a primitive log-hut in the first place, through all the refinements of carpentry, leaving nothing to chance, but settling with the utmost precision what, in the latter, suggested the various parts of the former. Chance in one case, and experience in another, however, are not enough for this author; but he also tells us that the Doric column was modelled by the Grecian colonists in Asia Minor, on the proportions of the male human figure, and was made six diameters in height, because a man was found to be six times the length of his foot; and that eventual improvements occasioned the column to be made one diameter more, or seven instead of six. "Thus the Doric column was first adapted to edifices, having the proportions, strength, and beauty of the body of a man!" The earliest examples of this order, however, are those which least agree with the primitive forms and proportions of Vitruvius; the columns at Corinth hardly exceed four diameters in height, while in later examples they gradually extend, till, in the temple of Minerva on the promontory of Sunium, the columns are nearly six diameters, being one of the tallest specimens of pure Greek origin ever executed. If the trunks of trees used in the structure of tents suggested the first idea of columns, and of the Doric in particular, as many contend, how is it that the earliest specimens discovered are the most massive? For the merest saplings would have formed the wooden proto-columns, and necessarily, when imitated in stone, they would not have been made more bulky than the less tenacious nature of the material required; much less would the slender wooden architrave have been magnified into the ponderous entablature of the primitive permanent architectural structures of all nations. In the construction of edifices with the trunks of trees, and timber generally, then, we do not find the origin of Doric architecture. If we have recourse to Egypt, the mother of the arts and sciences, we shall indeed find many things even in the more ancient structures which *may* have furnished an idea of the Doric arrangements to the fertile imagination of a Greek. The later works of that country cannot be trusted for originality, as they may themselves have been influenced by Greek examples; but we hardly dare assert that the Doric order was suggested by any thing in Egyptian architecture, though in making such assertion we should be supported by the opinions of many competent judges. The temple at Amada in Nubia can hardly be positively assumed as an example of the *proto-Doric*, though it may of the *proto-columnar*. Nevertheless, the example is striking, as it certainly possesses the Doric character. The broad square abacus, and the cylindrical or even conoidal tendency of the shaft, marked as it is, as if for fluting, with the plain, simple, and massive epistyle or architrave superimposed, are all in accordance with the Hellenic columnar ordinance; but still there is nothing to connect that rude model with the positive and somewhat formally arranged example at Corinth with which we began. It must be remembered, however, that two connecting links between Egyptian and Greek architecture are lost; Lower Egypt, with its splendid capital Memphis, and Phœnicia; through which latter the learning and taste of the inhabitants of the former country appear to have taken their course; but of neither of these do we possess architectural remains that bear on the subject in question. In the Pharaonic structures of Thebes we find both the tumescent and the cylindrical columns; and an amalgamation and modification of the two would easily produce the Doric column, or something very much like it, which may have been executed in those places, and so transferred to Greece. Of the triglyphs, the most distinguishing part of the Doric entablature, there are many indications in the early works of Upper Egypt; and in the structures of the Ptolemies they are still more evident; though it may be objected that, in these, those indications were borrowed from the Greeks after the Macedonian conquest. But it must be borne in mind that the Egyptian nation did not change its character, religion, or usages by the change of its governors; and the Egyptians were, through the whole period of their existence as a nation, an originating and not an imitative people; whereas the Greeks seized on a beauty wherever they found one, and made it their own by improving it. The forms and arrangement, too, of many of the Greek mouldings, and the manner of carving to enrich them, are common in the earliest ornate works of the Egyptians; and such things are as strong evidence of community of origin, as the existence of similar words having the same meaning in different languages is of theirs. We may be asked, why the Greeks cannot be allowed to have originated that beautiful style of architecture which they brought to the perfection it displays in their works? To which we think it a sufficient answer, that it would be against the common course of events if it were so. In Egypt we can trace a progress from the ruder to the more advanced, and, with trifling discrepancies, to the most perfect; but in Greece, the earliest specimen of columnar architecture that presents itself displays almost all the qualities and perfections which are found in works of periods when learning and civility were at their acme in that country. We cannot find in Greece a stepping-stone from the Celtic or Pelasgic Gate of the Lions of Mycenæ, to the Doric columns at Corinth, and hardly to the Fane of Minerva in the Acropolis of Athens; and have therefore to seek the gradations among the people with whom we have seen they were connected, and whose country furnishes them in a great measure, if not entirely. Differences in climate and in political constitution, as well as in forms of religion, account sufficiently for the differences between the arrangements of the religious structures of the Greeks and those of Egypt. At the present day we find, that though they may be built in the same style, and for the worship of the same divinity, there is a wide difference between a church in Italy and a church in England, and a still greater between a church in the former country and

Plate LV.

[1] Vitruvius, lib. i. cap. i.

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one in Scotland. The model, however, of the Greek temple is found in many places in Egypt, generally placed as a chapel or ædicula, subsidiary to, and in connection with, the larger structures, as well as in the earlier Nubian temples themselves.

None other than the Doric style or order was used in Greece till after the Macedonian conquest, about which period that beautiful and graceful variety called the Ionic was brought into use. It is as difficult to determine its origin as that of the Doric. Vitruvius says that the Ionian colonists, on building a temple to Diana, wished to find some new manner that was beautiful; and by the method which they had pursued with the Doric, proportioning the column after a man, they gave to this the delicacy of the female figure; in the first place by making the diameter of the column one eighth of its height, then by putting a base to it in twisted cords, like the sandals of a woman, and putting volutes to the capital, like the hair which hangs on both sides of her face. To crown all, he says that they channelled or fluted the column, to resemble the folds of female garments, by which it would appear that Vitruvius did not know that the Greeks never executed the Doric order without fluting the columns. "Thus," he goes on to say, "they invented these two species of columns, imitating in the one the naked simplicity and dignity of a man, and in the other the delicacy and the ornaments of a woman." It can hardly be doubted that the voluted or Ionic order did originate in Ionia, at least we know of no earlier examples of it than those which exist there; and it does not appear to have been known to the European Greeks, and certainly was not practised by them, till after the period we have indicated. It probably took its rise from some peculiarities in Persian architecture; though many believe that the Ionic order had a much earlier origin, deriving it from Egypt, where, it is true, many indications are found of its volutes in the spiral enrichments of capitals; but it must be observed that they are in edifices now ascertained to be of the age of the Ptolemies, and consequently later than the structures which exhibit the voluted order in Ionia and its islands. We think, too, that many persons are influenced in assigning a higher degree of antiquity to this style than facts will bear out, by their respect for the authority of Vitruvius; though Mr Gwilt (his latest translator into English) confesses that "upon his authority in matters of historical research not much reliance is to be placed."[1] We are willing to admit that much may be adduced in support of the opinion, that this style was known and used in Greece even before the age of Pericles; specimens of it having been found in connection with sculpture, certainly less perfect, and therefore presumed to be of earlier date, than the works of Phidias and his pupils and compeers.

It is no less difficult to determine the origin of what is called the Corinthian order. The not inelegant traditionary tale by Vitruvius of the invention of its capital, is the only *reason* of the name it bears. His account of the origin of this third species of columnar composition is more summary, and not less absurd, than that of the preceding. He says that it was arranged "to represent the delicacy of a young girl whose age renders her figure more pleasing and more susceptible of ornaments which may enhance her natural beauty." With much more reason might the Doric be called the Corinthian order; for, as we have stated, at Corinth there exists the oldest example of that style; whereas there is nothing, either in ruins or authentic record, to prove that the latter was ever known in that city. Columns with foliated capitals are not of very early date in Greece; earlier exist in Asia Minor, and foliage adorns the capitals of columns in some of the Pharaonic monuments of Egypt; not arranged, indeed, as in the later Corinthian capital, which by possibility may have been the result of some such accident as Vitruvius relates of Callimachus and the basket on the grave of the Corinthian virgin. The interior of the temple of Apollo Didymæus at Miletus in Ionia exhibits the earliest example of the acanthus leaf arranged round the drum of a capital in a single row, surmounted by the favourite honeysuckle; but that edifice was constructed about a century before Callimachus is understood to have lived. The only perfect columnar example in Greece itself of this species of foliated capital is of later date than, and is a great improvement on, that of Miletus; it is the beautiful little structure called the Choragic monument of Lysicrates at Athens. Specimens are less uncommon in Greece of square or antæ capitals, enriched with foliage, than of circular or columnar capitals; but they are almost invariably found to have belonged to the interior of buildings, and not to have been used externally. In considering Greek architecture, it is necessary to bear in mind that it ceases almost immediately after the subjection of Greece to the Roman power; for there are many edifices in that country in the style of columnar arrangement of which we are now speaking besides those referred to, but they belong to Roman and not to Greek architecture. The earliest of them perhaps, and certainly the least influenced by Roman taste, is the structure called the Tower of the Winds, or of Andronicus Cyrrhestes, at Athens. A spurious example of Greek Doric, evidently executed under the Roman domination, may be referred to here; it is that of the Agora, or Doric portico, as it is sometimes distinguished, in the same city.

Besides the three species of columnar arrangement we have enumerated, the Greeks employed another in which statues of women occupied the place of columns. The *reason* of this too Vitruvius furnishes in a story which is, as usual, totally unsupported by history or analogy; but the consequence of it is, that such figures are called Caryatides; and the arrangement has been called by some the Caryatic order. The use of representations of the human and other figures with or instead of columns is, however, common in the structures of Egypt and India; and to the former the Greeks were doubtless indebted for the idea, though they appear to have restricted its application to human female figures. Mr Gwilt infers, from various facts connected with the worship of Diana Caryatis, "that the statues called Caryatides were originally applied to or used about the temples of Diana; and instead of representing captives or persons in a state of ignominy (as the Vitruvian story goes), were in fact nothing more than the figures of the virgins who celebrated the worship of that goddess."[2]

The only architectural works of the Greeks that remain to us of any consequence, besides temples, propylæa, and Choragic monuments, are theatres; but these latter do not retain any thing connected with architectural decoration to make them interesting, except to the architect and antiquary. They are generally situated on the side of a hill, and were rather excavated or carved out in the earth or rock, than built; except the proscenium and parascenium, which being at the lower part, in front, and requiring elevation, must of necessity be built; but very little of the constructed portions in any case exists. It does not appear that the theatres afforded any provision for sheltering the spectators, or indeed the ac-

[1] Gwilt's *Chambers's Civil Architecture*, p. 30.

[2] *Ibid.* p. 57.

tors, from rain, except perhaps a covered cyrtostylar colonnade within the upper boundary wall, which, even when it existed, was of necessity very narrow and small for so large a number of people as were generally assembled; for the theatres were calculated to hold from five to fifteen and even twenty thousand persons. This, to say the least of it, must have subjected the public to great inconveniences, even in so fine a climate as that of Greece; for they were unsheltered from the sun at all times, and effectually debarred of a favourite amusement in wet weather.

No remains exist of the domestic structures of the Greeks; and we are too well aware, from the example of others, of the futility of following mere descriptions on the subject, to attempt it here; especially as the most explicit are those of Vitruvius, whom we know to have been ignorant of the arrangement of Greek temples, by those of them which exist, and may therefore reasonably suspect of ignorance with regard to things of which we have no remains. It may be taken for granted that the houses of the Greeks were less extensive than those of the Romans, as they were a poorer and less luxurious people; and we shall be able to determine those of the latter nation with great exactitude, from the actual remains of Roman towns and country mansions. The exquisite beauty of form and decoration which pervades every article of Greek origin, whether coins, medallions, vases, implements of war or husbandry, or even the meanest article of domestic or personal use of which we have specimens or representations, is evidence of the fine taste with which the mansions of the Greeks were furnished. However, ignorance of the use of the arch, inferior carpentry, the absence of glass, and ignorance of the use of chimneys, were disadvantages which the Greeks laboured under in the construction and convenient arrangement of their houses, that no degree of taste and elegance could completely countervail.

In the construction of their edifices, the Greeks seldom, if ever, had recourse to foreign materials; the stone used in their temples being almost invariably from the nearest convenient quarries, which supplied it of sufficiently good quality. The structures of Athens are built of marble from the quarries of Pentelicus, and those of Agrigentum of a fossil conglomerate which the place itself furnishes.

We have taken it for granted that the Greeks were ignorant of the properties of the arch, having too high an opinion of their good sense to think that they could be acquainted with so admirable and useful an expedient, and never use it; and no instance of its adaptation occurs in the construction of Greek edifices before the connection of Greece with Rome took place. Whether its invention should be referred to Italy or not is another question. If the great sewer at Rome called the Cloaca Maxima was constructed in the time of Tarquinius Priscus, it must be conceded that the properties of the arch were known and practised in that country at an earlier period than we know the principle to have been understood and applied elsewhere; for neither Egypt nor Greece, nor any of the Grecian colonies, can furnish evidence that it was known to either Egyptians or Grecians till a long time after the period referred to, and when it may have been communicated from Italy. But it is contended that the Cloaca Maxima, as it now exists, is a work of much more recent date, and that it may have succeeded the sewer constructed by the first Tarquinius, who was moreover himself a Greek. If the first part of the objection be correct, the evidence in favour of Italy is destroyed, as far as that work is concerned; the second is fallacious, because it is not necessary that the monarch should have brought the knowledge with him; though indeed he might have acquired it in Etruria, or it might have existed in Rome before his arrival there. Most writers on the subject are of opinion that the principle of the arch was not known, in Europe at least, nor to the nations of Western Asia and Africa, till after the Macedonian conquest, about which time it may have been invented, or acquired from some of the eastern nations who were visited by the conquerors. To these suggestions the objections hold that the arch was not applied in Egypt in the architectural works which remain of the Ptolemies, nor is it found in the Persian and Indian monuments which date beyond that period. The author of the *Munimenta Antiqua*, after a comprehensive review of all the authorities and examples on the subject, gives it as his own opinion that "Sicily was the country where this noble kind of ornament first appeared, and that Archimedes was the inventor of it."[1] The evidence appears, we think, generally stronger in favour of its Italian origin; but to whomsoever the invention may be attributed, and whensoever it was made, the Romans were the first to make extensive practical use of it; and by means of it they succeeded in doing what their predecessors in civilization never effected. It enabled them to carry permanent and secure roads across wide and rapid rivers, and to make a comparatively frail and fragile material, such as brick, more extensively useful than the finest marbles were in the hands of the Greeks without that principle. To the Greeks, however, the Romans were indebted for their knowledge of the more polished forms of columnar architecture; for, before the conquest of Greece, the structures of Rome appear to have been rude and inelegant. The few specimens of architecture which exist of date anterior to that period evidently resemble the works of the ancient Etrurians, who, though they had made considerable advances on the architecture of their Pelasgic ancestors, were far inferior in taste and refinement to the Greeks; yet it is to that people we are inclined to attribute the invention of the arch, from whom the Romans acquired their knowledge of its use, and that degree of civilization which they possessed before the epoch referred to. It may be presumed that the Etrurians had also originated the style of columnar architecture which Vitruvius describes and calls Tuscan; but as no example of it exists, at least nothing that answers his description of it, we cannot tell positively what it really was; for, as we have before remarked, descriptions without a model, of architecture particularly, are quite unintelligible, as far as understanding a new style goes. Whatever then was the style of architecture in Rome before the conquest of Greece, it was either exploded by the superior merit and beauty of what the Romans found in that country, or combined with it, though frequently the combination tended to destroy the beauty of both. In the porticoes of the temple of Antoninus and Faustina, and of the Pantheon, at Rome, the chaste simplicity of a Greek columnar composition is preserved; and in the magnificent dome of the latter edifice, and in the long extended aqueduct, it is fully equalled. But the triumphal arch of the Romans, a hybrid composed of columns and arches, is devoid alike of simplicity and harmony, indeed of every quality which constitutes beauty in architecture.

Roman architecture.

In the transference of Greek columnar architecture to Rome, a great change was effected, independently of those combinations. The less refined taste of the Romans

[1] *Munim. Antiq.* by Edward King, Esq. F.R.S. and S.A. vol. ii. p. 268.

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could not appreciate the simple grandeur and dignified beauty of the Doric, as it existed in Greece. They appear to have moulded it on what we suppose their own Tuscan to have been; and the result was the mean and characterless ordinance exemplified in the lowest story of the theatre of Marcellus at Rome, and in the temple at Cora, between 30 and 40 miles south of that city. Not less inferior to the Athenian examples of the Ionic order, than the Doric of Cora is to the Doric of Athens, are the mean and tasteless deteriorations of them in the Roman temples of Manly Fortune and Concord. It was different, however, with the foliated Corinthian, which became to the Romans what the Doric had been to the Greeks—their national style. But though they borrowed the style, they did not copy the Greek examples of it. In Rome the Corinthian order assumed a new and not less beautiful form and character, and was varied to a wonderful extent, but without losing its original and distinctive features. The example of the temple of Vesta at Tivoli hardly differs less from that of the temple of Jupiter Stator in Rome, than the latter does from the ordinance of the Choragic monument of Lysicrates at Athens; and all three are among the most beautiful examples of the Corinthian order in existence—if indeed they are not pre-eminently so—and yet they do not possess a single proportion in common. It must be confessed, moreover, that if the Romans had not good taste enough to admire the Doric and Ionic models of Greece, they had too much to be fond of their own, for they seldom used them. Both at home and abroad, in all their conquests and colonies, wherever they built, they employed the Corinthian order. Corinthian edifices were raised in Iberia and in Gaul, in Istria and in Greece, in Syria and in Egypt; and to the present day Nismes,[1] Pola, Athens, Palmyra, and the banks of the Nile, alike attest the fondness of the Romans for that peculiar style. We cannot agree with the generally received opinion, that Greek architects were employed by the Romans after the connection between the two countries took place; for the difference between the Greek and Roman styles of architecture is not merely in the preference given to one over another peculiar mode of columnar arrangement and composition, but a different taste pervades even the details: though the mouldings are the same, they differ more in spirit and character than do those of Greece and Egypt, which certainly would not have been the case if Roman architecture had been the work of Greek architects. Indeed, were it not for historical evidence, which cannot absolutely be refuted, an examination and comparison of the architectural monuments of the two countries would lead an architect to the conclusion, that the Corinthian order had its origin in Italy, and that the almost solitary perfect example of it in Greece was the result of an accidental communication with that country, modified by Greek taste; or that the foliated style was common to both, without either being indebted to the other for it. The Romans conquered Egypt as well as Greece, but we do not find that they adopted any of the peculiarities of Egyptian architecture. They carried away indeed the obelisks and many of the sculptures of Egypt, as trophies of their conquests or as ornaments of their city; but they neither made obelisks nor constructed temples to Egyptian divinities in the Egyptian style. If, however, Greek architects were employed by the Romans, they must have made their taste and mode of design conform to those of their conquerors much more readily than we can imagine they would as the civilized slaves of barbarian masters; and it is too clear to be disputed, that the Roman architecture is a style essentially distinct from the Greek. This is elucidated by the fact that many of the minor works of sculpture in connection with architecture, such as candelabra, vases, and various articles of household furniture discovered at the villa of Adrianus, near Rome, and at Herculaneum and Pompeii, are fashioned and ornamented in the Greek style, while others are as decidedly Roman in those particulars; rendering it evident that such things were either imported from Greece, or that Greek artists and artisans were employed in Italy, who retained their own national taste and modes of design. It is probable, nevertheless, that both the architects and artists, natives of Rome, qualified their own less elegant productions by reference to Greek models; but that the Romans derived their architecture entirely from the Greeks, may certainly be disputed.

Half the extent and magnificence of the architectural works of the Romans is attributable to their knowledge and use of the arch, which enabled them, as we have already intimated, to make small parallelopipedons of burnt earth more extensively applicable to useful purposes than any other material could be, from the greater cost of providing and preparing it; whereas brick can, in almost every place, be made on the spot in which it is wanted. There is a very false notion abroad as to the richness of the materials used for building in Rome, induced by the inflated accounts of travellers and poets, who attempt to disguise their ignorance, or their want of knowledge and taste, by raving of Vitruvian proportions, and marble temples, palaces, and baths. The truth is, that Rome was built, not of marble, nor even of stone, but of brick; for in comparison to the quantity of brick, it may be safely asserted that there is more stone in London than there was in imperial Rome. Almost all the structures of the Romans indeed were of brick—their aqueducts, their palaces, their villas, their baths, and their temples. Of the present remains, it is only a few columns and their entablatures that are of marble or granite, and two or three buildings of Travertine stone;—all the rest are brick. The Colosseum, the Mausoleum of Adrian, the Cloaca Maxima, the Temple of Manly Fortune, and the ancient bridges on the Tiber, are of Travertine stone; the remaining columns of the more splendid temples, the internal columns and their accessories of the Pantheon, the exterior of the imperial arches, and the cenotaphial columns of Trajanus and Antoninus, are of marble: but the Imperial Mount of the Palatine, which holds the ruins of the Palace of the Cæsars, is but one mass of brick; the Pantheon, except its portico and internal columns, &c. is of brick; the Temples of Peace, of Venus and Rome, and of Minerva Medica, are of brick; and so, for the most part, were the walls of others, though they may have been faced with marble or freestone. The Baths of Titus, of Caracalla, and of Diocletianus, are of brick; the city walls are of brick; so are the extensive remains of the splendid villa of Adrianus near Rome;

[1] Bordeaux *did.* A century and a half ago there existed at Bordeaux very considerable remains of a most interesting Roman edifice, of which no authentic record is preserved but a slight sketch by Perrault, the architect of the great front of the Louvre, who delineated it a few years before its destruction by the government, and who termed it one of the most magnificent and most entire of the Roman monuments then remaining in France. The editor of the new edition of Stuart's Athens, speaking of this, says, "on this occasion the reflection presents itself, that while the Turks are reprobated for appropriating the columns of ancient Athens, in their haste to raise a wall to defend their town from the predatory Albanians, here, in the vaunted age of Louis XIV. (in his kingdom and under his government, may be added) the finest production of ancient architecture in France was more recklessly demolished to make place for the fortifications of Bordeaux, deliberately constructed by Vauban; and no architect, either of the city or government, has preserved for posterity the details of so noble a monument." (*Antiquities of Athens*, new edition, vol. iii. c. xi. p. 120.)

the villa of Mecænas at Tivoli; the palaces of the Roman emperors and patricians at Baiæ and in other parts of Italy; and so, it may be said, are the remains of Herculaneum and Pompeii, for the houses in those cities are generally built of alternate double courses of brick, and courses of stone or lava. In most cases, at Rome and in the provinces, stucco formed the surface which received the decorations. From the above enumeration, it will appear how much more variously the Romans built than any of their predecessors in civilization did. In Egypt we find no indications of edifices of real utility or convenience, nothing but temples and tombs,—and in Greece there is but a small addition to this list; but in Rome are found specimens of almost every variety of structure that men in civilized communities require. Much of this also may be attributed to the knowledge they possessed of the properties of the arch, which may be considered among the most admirable and useful discoveries ever made in the practical applications of mechanical science. It entered into the composition of every structure, and made the rudest and cheapest material of more real value than the most costly. It not only superseded the use of long stone beams, but was constantly used in places where indeed joists of wood would have been much more convenient, giving support to the opinion that even the Romans were not skilled in the application of timber to their edifices; though, on the contrary, it is difficult to understand how Rome could become subject to such a dreadful conflagration as that which occurred in the reign of Nero, if timber had not been employed in the ordinary houses of the city to a much greater extent than would appear from existing remains. The domestic structures of Herculaneum and Pompeii were evidently never very susceptible of fire, from the small quantity of timber required in their construction; and discoveries which are made from time to time, of portions of the ordinary houses of ancient Rome, under the pavements of the modern city, evince that they were very similar to them in almost every particular. The infrequency of stairs, and the meanness of those which exist, leading to upper apartments in the houses of those cities, leads to the belief that the Romans seldom built above the ground story, and that their skill in carpentry was not very great; otherwise they would more frequently have had recourse to so easy and convenient a mode of extending room as upper stories offer. There are, however, other things which tend to prove that carpentry was well understood by the Romans; and the most remarkable is the bridge that Trajan built over the Danube, the piers of which are said by Dion Cassius to have been 150 feet high and 170 feet apart. Now, whether the bridge itself consisted of a wooden platform, as there is much reason to believe, or was of stone arches, as the historian intimates, the skill which constructed centring for the latter, or laid the platform from pier to pier in the former case, of that immense extent, was amazing; nevertheless, such skill in carpentry is not convinced by the remains of the civic and domestic structures of the Romans, in which arching in all its varieties was used where carpentry would have been better. Of their joinery we know nothing; but it does not appear, from the last-quoted mode of ascertaining such things, to have been much practised by them—mosaic pavements supplying the place of flooring, and stucco that of wainscoting: the luxury of windows being unknown, their fittings were not required; and doors, it would appear, were uncommon, except externally—the internal doorways being most probably covered with something equivalent to the quilted leather mats suspended from the mantel, which are used instead of swinging doors at the entrances of the churches in Italy at the present time. Although the Romans did not use marble to the extent that has been supposed, yet they were extremely luxurious in the use of costly stones. Marbles of every variety, and from all parts, were used in Rome; and columns were made of Egyptian and other granites, and porphyry. In Greece, and the Grecian colonies which were conquered by Rome, the edifices of the Romans might be distinguished by the foreign marbles used in them, if the style of their execution were not sufficient otherwise to determine them.

The mingling of columnar and arcaded arrangements in the same composition appears to have been the grand cause of the deterioration of Roman architecture. It occasioned unequal and inordinately distended intercolumniations and broken entablatures: these a vitiated taste repeated, where the necessity that had first occasioned them did not exist; and harmony and simplicity being thus destroyed, the practice of the science went on deteriorating, till it was made to produce such monstrous combinations as the Palace of Diocletian at Spalatro, and the Temple of Pallas, or ruins of the Forum of Nerva in Rome, present. It was indeed a fall from the grandeur, harmony, and noble simplicity of the interior of the Pantheon in its pristine state, to the hall or xystum of the baths of Diocletian, which now exists as the church of Santa Maria degli Angeli, with its straggling columns and broken and imperfect entablature; or from the temple of Jupiter Stator to that of Concord or the arch of Septimius Severus.

Architecture was already extinct among the Romans when the seat of empire was transferred to Constantinople; so that, however great was the extent and splendour of its edifices, we cannot suppose them to have possessed any of those qualities which give to the Parthenon at Athens, and to the interior of the Pantheon at Rome, the charm they possess; unless the Greeks had recourse to the monuments of their own country, and used them as founts from which to draw matter for the composition of the edifices of their new capital. This, indeed, is possible, for there appears to have been, even in Rome, at and after the time of Constantine, a recurrence to the ancient simplicity, though, truly, without any of that beauty and elegance of form in the details, and of proportion in the general arrangement, which constitute half the merit of works of architecture. The change of religion which took place under Constantine led to the destruction or destitution of many of the noblest structures in Rome. The ancient Christian basilicas are for the most part constructed of the ruins of the more ancient Pagan temples, baths, and mausoleums; and in them a much greater degree of simplicity, and consequent beauty, pervades the columnar arrangements than existed perhaps in some of the previous combinations of the same materials. Frequently, however, the collocation of various parts was most unapt; and gross inconsistencies were recurred to, to get rid of the difficulty of combining discordant fragments. Sometimes it was necessary to make up with new, what was wanting of old materials, whose forms were rudely imitated.

Gothic or Pointed architecture.

In those countries which received the Christian religion from Rome, but which did not contain mines of architectural material in temples, amphitheatres, and palaces, as Italy did, and indeed in the other parts of Italy itself which did not contain them as Rome did, churches were constructed in imitation of those of the metropolis of the Christian world. These, being the work of a semi-barbarous and unpolished people, were of necessity rude and clumsy. Hence arose the Gothic architecture of the middle ages, and not from any previously existing style of architecture among the northern nations who overran Italy and subverted the Roman power. The rude Celtic

History. monuments were the only specimens of architecture they possessed, and the performance of their unhallowed rites appears to have been long transferred even from them to the groves, or it may be that the stone circles and temples themselves were called groves. This, however, is of but little consequence to our purpose. The fact is indisputable, that nothing existed among those nations that could have given rise to the rude style of architecture referred to, which was indeed introduced to them by the Christian religion in the manner we have stated. It will be found in what are called the Saxon and Norman styles of this country, and to a greater or less extent in all the countries of Europe in which the Romans had been masters, and particularly in those which adhered to the Roman communion in the great division of the churches. The general forms and modes of arrangement peculiar to Roman architecture may be traced throughout; in some specimens they are more, and in others less obvious, but the leading features are the same. This is more evident in Italy than elsewhere. In the early Roman basilicas and churches, some of which are of the Constantinian age, and which were constructed with the matter and in the manner related, the first divergencies occur; in those which are later they are still greater, and distance of time and place appears still to have increased them, till what may be called a new style was formed, having peculiarities of its own, but yet more clearly deducible from its origin than Roman is from Greek or Greek from Egyptian. As might be expected, this style was not the same in all the countries which practised it; it was derived, in them all, from the same source as we have shown, but was materially influenced by the habits, manners, and state of civilization in which the various nations were, and much too by their means of communication with Rome. This, with strict propriety, may be called Gothic architecture, as it was partly induced by the Gothic invasions of Italy, and was most generally practised by the nations to whom that term may with equal propriety be applied. It arose in the fourth century, and was subverted in the twelfth by the invention or introduction of the pointed arch, which marks a new era, and was destined to give birth to a new style in architecture. Where, when, and by whom it was invented or originated, has been more discussed and disputed than the discovery of the properties of the arch itself. Some have contended that it was suggested by the intersections of semicircular arches, as they were employed in ornamenting the fronts of edifices in the preceding style; some, that groined arches of the same form gave the idea; others have referred it to the interlacing of the branches of trees when planted in parallel rows,—to an imitation of wicker-work,—to a figure used on conventual seals,—to the principle of the pyramid,—to Noah's Ark, —to chance. Its invention has been accorded to almost every nation, civilized and uncivilized. It has been claimed by Germans for Germany, by Frenchmen for France, by Scotsmen for Scotland, and by Englishmen for England. Italians have not directly laid claim to the honour for themselves, but it has been given them by others. Such a mass of conflicting opinions, almost all supported by some show of reason, and more or less by evidence, may be called a proof of the impossibility of determining the question, and therefore we shall not attempt it. There is one striking fact, however, which has been too much overlooked by many of the theorists in the discussion of the question; it is, that the pointed arch made its appearance almost at the same moment of time in all the civilized countries of Europe. This is proved by the controversies of those who, more patriotically than philosophically, claim its invention for their respective nations; for none of them can produce genuine specimens of it before a certain period, to which they can all reach. Now, if it had been invented in any of the European nations, that one would certainly have been able to show specimens of it of a date considerably anterior to *some* of the others; for though it might by chance have been soon communicated to any one of them, the improbability is great that it would have reached them all, and have been adopted by all, to the subversion of their previously existing style of architecture, immediately. The infrequent and imperfect modes of communication between the different countries of Europe at the period referred to, furnish another reason why it is not probable that a discovery of the kind should travel rapidly from one to another. Considering these things, and particularly the fact of the almost simultaneous introduction of the pointed arch to the various nations of Europe, as it appears by their monuments immediately after the first crusade, in which they all bore a part, connected with existing evidence that it was commonly used in the East at and anterior to that period, it seems to be the most rational theory, that a knowledge of it was acquired by the crusaders in the Holy Land, and brought home to their respective countries by them. This, indeed, is the opinion of many of those who have written on the subject; and without contending that the evidence in its favour is quite conclusive, we think it more satisfactory than any other. In Europe there are found rude approaches to the pointed arch in some of the earlier Gothic structures; but we believe it may be safely asserted, that nothing can be indicated of a date beyond that of the first crusade, approaching the simple but perfect lancet arch, which, it is not denied, came into use immediately after that period; whereas tolerably well authenticated examples of it are found in the East, of sufficient antiquity to induce the opinion that it was at that time imported from thence. It is, moreover, indisputable that the Saracenic or Mahometan nations do use, and have used, the pointed arch; but they were never known to adopt any European custom or invention of any kind till very lately. How then can they be supposed to have availed themselves so readily as they must have done, if it be of European origin, of so unlikely a thing to attract a Moslem's attention, as the peculiar form and structure of an arch? and when and where in Europe had they an opportunity of contemplating it till long after it is admitted to have been in common use among them? With what nation of the East, and in what manner, the pointed arch originated, are points equally difficult to solve. We have not been able to discover that the properties of the arch were known to the Egyptians or the Greeks, and much less so were they to the Persians and Indians, till it may have been communicated from Italy; but structures are found among those nations, in which chambers are domed, and apertures headed, in the form of a pointed arch, but produced by battering or corbelling over. It is not improbable, therefore, that such things being before the eyes of men, when the principles of the arch had been acquired, that form would be repeated upon it, and the result would be the lancet arch,—the prototype, the germ of the style. The pointed arch, on its introduction into Europe, does not appear to have been accompanied by its ordinary accessories in after-time; its light clustered pillars—its mullions, foliations or featherings, and graceful tracery—these resulted from its adoption: so that whether the arch itself was invented in Europe, or imported from the East, to the European nations must be assigned the credit of educing the beautiful style of architecture whose distinguishing feature it is.

It may be doubted whether Venice was not the parent of the style, for very early specimens of the pointed arch

re certainly found there, in private houses as well as in he basilica of St Mark. In the former they are genally of the ogee or contrasted form, in windows formed by olumns or mullions, with, in certain places, approaches to bliations and tracery; and in the basilica the lancet arch not uncommon. The commercial connection of that city ith the eastern nations may easily account for its presence here, even before the first crusade; and Venice is known have been one of the thoroughfares from the other arts of Europe to the Holy Land. But the peculiar ode of arrangement in the Venetian style does not apear to have been adopted north of the Alps; so that, owever original it may be, it can hardly be considered e progenetrix of the school, or the model on which it was rmed.

Before proceeding further with this subject, it is necesry to determine by what name to call the style whose ogress we have yet to contemplate. There would be greater propriety in calling it Saracenic because its disnctive feature originated in the East, even if that point ere conceded, than in calling all architectural combinaons which derive their character from the use of comns in them by the name of the nation in whose works e find columns first used, and from whom the idea of em may have been acquired. Neither can it with any egree of fitness be called Gothic: that term, we have en, applies to the style that preceded it, and was first ven to the pointed-arch style opprobriously, during the fuscation of good taste that succeeded its subversion. Italy it had never taken root, as in the countries north the Alps—the ancient Roman monuments having conued to influence the national architecture, it would apear, throughout the middle ages; for the ecclesiastical ructures of that country, though rude, were never so de as they were in other places, and a better style had far formed itself before the introduction of the pointed ch, that it was hardly received there. Indeed, whatever lifices of merit Italy possesses in its manner, are, with rdly an exception, by German architects, few Italians ving ever qualified themselves to practise it. When, erefore, what has been called "the revival of architecre" took place in the fifteenth century, under Brunelschi and his successors, the rude structures of their own untry, the precursors and contemporaries of our Saxon d Norman edifices, were called Gothic; but the pointed yle was always distinguished as the German manner, *laniera Tedesca*. The disgrace of applying the opprous term Gothic to it attaches itself to an Englishman, r Henry Wotton, who wrote on architecture early in the venteenth century. It was continued by Evelyn, who apied it more directly; and the authority of Sir Christoher Wren finally settled its application. Its injustice is, wever, rendered very obvious, by comparing the front Pisa cathedral, the best example, perhaps, of Gothic, merely deteriorated Roman architecture, with that of ork Minster, which holds an equal rank in the pointed yle. The presence of the pointed arch, on the singular ental-looking cupola of the former, shows it to be one the latest edifices in its style, overtaken by that before was completely finished. Within the last half-century better taste has been formed, in this country particurly, and has led to the appreciation of that, which is, ined, our national style; and within that period many tempts have been made to explode the universally-deied, unjust, and totally irrelevant appellation, but witht effect. Sir Christopher Wren himself attempted to ange it to Saracenic, believing that not merely the arch, t the style generally, was borrowed from the Saracens. was, however, too late—he had already used the other. r Stukely wished to call it Arabian. Some writers called it Italian, others German, others Norman or French, others British, and many have contended for the exclusive term English; and to this last the Society of Antiquaries lent its influence, but with equal inefficiency, for the term Gothic still prevails. Mr Britton, than whom perhaps no man possesses an equal right to affix an appellation to the pointed-arch style, from the splendid services he has done it in the publication of his Cathedral and Architectural Antiquities, wishes to introduce a term which is not at all unlikely to succeed, as it is equally appropriate and independent of national feeling and hypothetic origin. He calls it Christian architecture. This, as a generic term, would admit each nation possessing specimens of it to distinguish its own species or style; and as the varieties of Hellenic architecture are known by the names of the tribes or nations who are presumed to have originated them—Dorian, Ionian, and Corinthian—so might Christian architecture be English or British, German, French, &c. for each has its peculiarities. These species would again individually admit of classification, according to the changes each underwent in the course of its career. One strong objection, however, in our view of the case, lies to Mr Britton's distinctive appellation. It is, that "Christian" applies as well, if not better, to the real Gothic style—that which arose on the extinction of Roman architecture, and was subverted by the introduction of the pointed arch, and which, indeed, owed its diffusion and progress, if not its origin, to the Christian religion. We are therefore still left to seek an appellation; and, in the absence of a better, will use the term Pointed, which is not only distinctive, but descriptive; and it has, too, the merit of being general, so that it may mark the genus, while the national species and their varieties may be distinguished by their peculiarities as before.

The Pointed Arch was a graft on the Gothic architecture of northern Europe, as the circular arch of the Romans had been on the columnar ordinances of the Greeks; but with a widely different result. The amalgamation in the latter case destroyed the beauty of both the stock and the scion; while in the former the stock lent itself to the modifying influence of its parasitical nursling, gradually gave up its heavy, dull, and cheerless forms, and was eventually lost in its beautiful offspring, as the unlovely caterpillar is in the gay and graceful butterfly.

We have seen that architecture had its origin in religious feelings and observances—that its noblest monuments among the pagan nations of antiquity were temples to the divinity—that the rude nations of the north in the middle ages devoted their energies, after their conversion to Christianity, to the construction of edifices for the worship of the Almighty; and we find, again, that the most extensive and most splendid structures raised by the same people, when the light of learning had begun to shine upon them, and a new and more beautiful style of architecture was introduced, were dedicated to the same purpose. In addition, however, many, hardly less magnificent, and not less beautiful, were raised for the purposes of education, and became the nurseries of science and literature. Kings and nobles also employed architecture in the composition, arrangement, and decoration of their palaces and castles; but still, for domestic purposes, its aid was hardly required beyond the carving grotesque ornaments on the wooden fronts of houses in towns.

When the practice of building houses in stories commenced cannot be correctly ascertained; but it appears to have arisen during the middle ages. We frequently, indeed, find an apparent equivalent for the term *story* used by the ancient writers, both sacred and profane; but it must have reference to something else—some peculiarity of which we are not aware; for none of the ancient re-

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mains, whether of public or private structures, give reason to believe that it was a common practice even among the Romans; much less was it likely to be so among the eastern nations, with whom the practice is not very general, nor is it carried to great extent even at the present day. Indeed, without considerable proficiency in the art of construction, it is hardly practicable to build in stories with such slight materials as were used by the Romans in their domestic edifices; and their remains do not evince the requisite degree of proficiency. We find, however, in the oldest existing works of the middle ages, and particularly in some of the secular structures of Venice which are among them, a degree of intelligence evinced in that respect far surpassing any thing in those of the ancients. Possibly the skill was principally acquired in that city from the necessity of making artificial foundations, in the first place, which in their turn exacted walls not unnecessarily cumbrous; and to make slight ones sufficiently strong, they must be skilfully bonded in themselves, and bound together, which could only be done by means of a material possessing considerable length and great fibrous tenacity—whence framed floors of timber. These, by their strength, their obvious utility and convenience, added to the want of space which existed in a thriving and populous community on a very restricted spot of dry land, superinduced, in the second place, the building of additional stories, which would soon be imitated in other places. But in what manner soever the improvement took place, the fact is certain that the acquisition was made; and we find it applied in all the works of the European nations, both ecclesiastical and civil, from the ninth and tenth centuries downwards. The combination of masonry and carpentry in building tended greatly to the advancement of both; for, it being required at times to make them act independently of each other, additional science and art were necessary, as the proportions must be retained that were given to similar works in which they co-operated. Hence the wondrous skill evinced in the vaulted roofs and ceilings, in the towers and lofty spires, of some of our Pointed cathedrals for the one, and the splendid piece of construction in the roof of Westminster Hall for the other. To this point Sir William Chambers, who was no depreciator of the merits of the Romans in architecture, says, "In the constructive part of architecture the ancients do not seem to have been great proficients:"[1] then having referred many of what he calls the "deformities observable in Grecian buildings" to want of skill in construction, he continues, "neither were the Romans much more skilful; the precepts of Vitruvius and Pliny on that subject are imperfect, sometimes erroneous, and the strength or duration of their structures is more owing to the quantity and goodness of their materials than to any great art in putting them together. It is not, therefore, from any of the ancient works that much information can be obtained in that branch of the art. To those usually called Gothic architects we are indebted for the first considerable improvement in construction. There is a lightness in their works, an art and boldness of execution, to which the ancients never arrived, and which the moderns comprehend and imitate with difficulty. England contains many magnificent specimens of this species of architecture, equally admirable for the art with which they are built, the taste and ingenuity with which they are composed." To this Mr Gwilt, in his new edition of Sir William's work, adds in a note, "there is more constructive skill shown in Salisbury, and others of our cathedrals, than in all the works of the ancients put together."

Pointed architecture took root and grew with the greatest vigour in Germany and Great Britain, and in those provinces, principally, of France which were connected with England; but in this country its course is the most marked, and its advances are the most easily traceable. We find in various portions of the same edifice, according to the period of its construction, exemplifications of the style, from the ingrafting of the simple lancet arch on the Norman or Gothic piers in the time of Henry II. to the highly enriched groinings and ramified traceries of the age of Henry VII.; but the changes are so gradual, and are so finely blended, that the one in advance appears naturally to result from that which comes before it. Whether the nations of the Continent, then, borrowed from us, or were themselves originators, it is very clear that we did not borrow; for our structures bear the strongest possible marks of originality, as the advances can be traced from one thing to another on them; and such is not so completely the case with theirs. Moreover, the latest manner, and certainly not the least beautiful, the Corinthian order of Pointed architecture, is almost peculiar to this country. Neither Germany nor France can produce edifices in the style of St George's Chapel at Windsor, King's College Chapel at Cambridge, and Henry VII.'s Chapel at Westminster. The structures of Scotland in the Pointed style so much resemble those of England, that they must be considered of the same school; Roslin Chapel is one of the few specimens which indicate a connection with the Continent. Ireland contains but few examples in any degree of perfection, and they are, of course, of the English school. The German school was next in merit to the English in the practice of Pointed architecture. In the extent and magnificence of its attempts, perhaps, that country excelled; but few of the great structures in Germany were ever completed. In regularity, however, they have generally an advantage over those of England, being mostly in the same manner throughout, as far as they were carried; whereas few of the greater edifices of this country were begun and completed without considerable variations in the style. But the Germans were never so successful in the splendour and beauty of their interiors as the English; indeed in that particular our Pointed structures are strikingly superior to every other: nor is their ornament generally so effective as ours. The Flemish style of Pointed architecture is hardly a variety of the German, but may be classed with it through the whole course of its history. Italy, we have said, possesses but few structures in the Pointed style, and they are for the most part the work of German architects, which their appearance indeed bespeaks. Milan cathedral, or "the Duomo," as it is called, is the most renowned edifice in the style that Italy contains; but it has few beauties in the eyes of those who are accustomed to the models of Great Britain, Normandy, and Germany. The Patriarchal Church of St Mark at Venice is a genus *per se*. It was constructed by a Constantinopolitan architect in the ninth or tenth century, and may be a specimen of the architecture of the Byzantine capital at that time. The few examples in Sicily of the pointed arch may be attributed to the Norman conquerors of that island; and so indeed may most of those which are found in the continental part of the same kingdom. Although France contains many fine specimens of Pointed architecture, it can hardly be considered indigenous to that country. On the German frontier they resemble the German style; and in the provinces which were formerly connected with England they are different, and more like the English styles: cer-

[1] Gwilt's *Chambers's Civ. Arch.* p. 128.

tain it is, that after their connection with this country was broken off, its practice fell into disuse, and nothing of consequence in it was posteriorly produced in any of them. This fact is an argument against the presumption that England was indebted to Normandy and Norman architects for its improvements in Pointed architecture; it tends rather to prove the opposite. It must be confessed, moreover, that there is an air of cumbrous massiveness in the Pointed style of Normandy which renders it peculiar, and perhaps marks its more close relationship with the earlier Norman Gothic. Like the German examples, too, those of France are generally inferior in internal richness and beauty to those of England. Pointed architecture in Spain never acquired that degree of consistency and elegance which might justify us in speaking of the Spanish specimens of it as forming a style. The edifices in Spain of the ages of Pointed architecture are more in accordance with the Moorish than with the European manner, and may perhaps be more correctly considered as an off-shoot of the former than of the latter. Though not in the Pointed style, the Moorish or Saracenic structures in Spain may be referred to here. They are in a very peculiar manner, which, it would appear, their authors brought with them from the East. Probably it grew out of some of the earlier styles of architecture, as the Gothic and Pointed did out of the Roman, and was not the result of design. The really distinctive feature of the Saracenic style is the horse-shoe arch, which is the greater segment of an ellipsis, nearly, on a conjugate chord. The columns from which the arches are sprung are slender, and the superincumbent masses are broad and heavy, giving an air of the intermingling of Chinese and Egyptian, both of which this style may be said to assimilate. The enrichments of Saracenic architecture are very much confined to flat surfaces, the walls being sculptured all over with monotonous ornaments, which produce an effect very similar to that produced by the hieroglyphics on the flat surfaces of the Egyptian temples, and possibly were derived from them. The most distinguished monument of this style in Spain is the Alhamrā at Granada. The most distinguished specimen of Pointed architecture in Portugal is the church of the convent of Batalha, which was constructed by an Irish architect, who appears to have modified the style of his own country (the English), by the manner of the country itself, which is nearly that of Spain.

What the expansive dome is to Roman architecture, the graceful spire is to Pointed. Bell-towers appear to have been added to Christian churches at a very early period; but it is much to be doubted whether the pyramidal pinnacle or spire was ever used before the introduction of the pointed arch, though one or two doubtful examples exist. These, certainly the earliest specimens of it, are simple cones, whose vertical bisection would be nearly an equilateral triangle: the angle at the apex was gradually made less, and as it diminished the altitude was increased, till at length resulted an object even more beautiful than an Egyptian obelisk, which would of itself indeed be a sufficient warranty for the appellation we have given to the style that it crowns. The spire was at first round, solid, and unornamented; it then became polygonal, and finally octagonal, though there are examples of square spires. They were sometimes plainly ribbed, sometimes crocketed, and in some instances were pierced; and were almost invariably surmounted by a rich finial in the style of ornament peculiar to the time of its execution. In some cases the whole structure was a pyramis or spire, and in others the spire rested on a rectangular and upright tower. The Rev. W. L. Bowles has suggested that the spire was at first built on the bell-tower as a beacon or land-mark for the guidance of the traveller and the distant parishioner; and adduces as evidence, the fact, that in the hilly parts of England spires are hardly to be found except in modern churches. The old village church on a hill has a plain square tower, merely consisting of about two cubes, which can be seen at the greatest distance the nature of the country will allow any object to be distinguished; whereas in the level parts of the country, where a low tower would be lost amidst the foliage of its own churchyard, and be completely indistinguishable at a very short distance, spires are their almost invariable accompaniment. It may be added, that the tapering spire is almost unknown in Italy and France, except Normandy; and in no part of the Continent is it so common as in this country.

We have already given our reasons for thinking that the pointed arch originated in the East; but whether it did or did not, it has been very extensively used in various parts of Asia, and nowhere in more sumptuous edifices, or to such effect, as by the Mohammedan conquerors of India in various parts of that country.

Italian school of architecture.

The opening of the Italian school of architecture on the resuscitated dogmas of Vitruvius was the signal for the extinction of that of the beautiful Pointed style. Fortunately, however, its effects were a full century in reaching this country, and during that period many of our most elegant structures came into being; and many of those of earlier date which had been commenced before, or during the wars of the Roses, and left unfinished, were completed. The first indication we have of the presence of the *Cinquecentist*, the real Gothic, is in the tomb of Henry VII., which was executed by Torregiano, an Italian artist, who, it would appear, was obliged to have some respect to the style of the edifice in which his work was to rest; but his preconceived ideas of propriety and beauty were too strong to allow him to omit the characteristics of his school, and the result is a strange mixture of both. From that time the Pointed style was rapidly deteriorated, being overborne by the devices of Italy. On the Continent the latter were already predominant, for during the whole of the fifteenth century the current had been setting from Italy over every part of Europe which received its religion from Rome; and this country was only the last to be overwhelmed by it. Before quitting the part of the subject having reference to our national style of architecture, it may be well to controvert the absurd but too prevalent idea, that we are indebted to foreigners, and particularly Italians, for the excellence of our ancient works. After what has been already said, perhaps it may be unnecessary to do so here, seeing that we have described our specimens of the Pointed style as being not only fully equal in composition, construction, and execution to those of any other country, but that they are absolutely in a different manner, having peculiarities which no other nation has ever equalled in beauty and elegance. But, to put the case in a clear point of view: If foreigners were employed to design and execute for us, it is not less strange that they should surpass their own works at home, than that they should make inventions and improvements for us (or let them be called mere variations) which were not in turn executed in their own countries. We know very well that works of architecture and sculpture which have been executed by foreigners in this country, since the explosion of Pointed architecture, are in the style of Italy or France, and not according to the manner prevalent in this country at the time of their execution. Moreover, for one whole century this nation alone adhered to the Pointed style, during which works were produced, that, for originality, exuberance of fancy, and beauty, spirit, and excellence of ex-

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If the architecture of Italy never fell away so much from the more classic style of Imperial Rome as that of the northern nations did, neither did that country ever possess that more than equivalent, whose splendid course we have last noticed. Whilst the Pointed style was almost exclusively known and practised in Germany, France, and the British Islands, the Italians were gradually improving on their Gothic style; yet the improvement was more evinced in their secular than in their ecclesiastical structures. Florence, Bologna, Ferrara, Venice, and many other cities of Italy, contain palaces and mansions of the twelfth, thirteenth, and fourteenth centuries, which for simplicity and classical beauty far excel most of those in the same and other places of the three subsecutive centuries. The contemporary churches, however, do not exhibit the same degree of improvement, forming, as it were, an anomaly in the history of architecture; a change in it being first developed in secular structures, and then applied to those devoted to the worship of the divinity; for many of the churches of the fifteenth century are in this, which may be called the early Italian style, or *Trecento*, as that which followed it is known as the *Cinquecento*.[1] Circular arches, and plain continuous horizontal cornices, and pilasters but slightly projected, with simple but generally tasteful and elegant enrichments of foliage and carved mouldings, are the most striking characteristics of the *Trecento;* but columns, and the arrangements depending on them, except as collocated with pilasters, are very infrequent in it. In various parts of Italy, and particularly in Venice and some of the Venetian cities, this style produced many of its best works, both secular and ecclesiastical, even during the fifteenth century; but it gradually gave way to, though in some instances its influence may be traced even when it had been overborne by, the new style.

The first step taken towards the reformation of architecture was by Filippo Brunelleschi, a Florentine architect, who was employed to finish the cathedral or duomo of his native city early in the 15th century; a work which had been commenced more than a century before on the design of Arnolpho, a Florentine also, but which still required the cupola when its completion was intrusted to Brunelleschi. The edifice is in the Italian Gothic style, slightly modified by what we have termed the *Trecento*, which his superior taste and talent induced him to attempt to supersede, and bring the world back to the classic style of ancient Rome. The construction of the cupola gained him great reputation and the confidence of the public, which he employed to advance his favourite scheme. To use the words of an Italian writer on the subject, "On the example of so wise and skilled a man, other architects afterwards devoted themselves to free architecture of the monstrosities introduced by barbarism and excessive license, and to restore it to its primitive simplicity and dignity."[2] But to what did they have recourse to effect this? Did they examine and study the remains of antiquity in Greece and Rome, in Italy and elsewhere? No! they referred to the writings of an obscure Latin author, who professed to give the principles and practice of architecture among the Greeks and Romans, but paid no more attention to the existing architectural works of those nations than if they had never been, although one could hardly walk the streets of any of the old cities in the south of Italy without seeing Roman edifices, whilst Rome and its vicinity was, as it still is, full of them. All the use, however, that these self-called "restorers" of architecture made of the works of the ancients, was to use them as lay-figures, or frame-work, to model on, according to the proportions and directions given by Vitruvius; and the effect was formality and mannerism in those who adhered to the dogmas of the school, and wild grotesqueness in those who allowed themselves to wander from them, whilst simplicity, and its consequence good taste, were effectually banished from the works of them all.

It will be necessary here, perhaps, before we advance further in our remarks on the Italian school, to disabuse the public mind as to the merit of the works of Vitruvius, whose anilities have so long passed for authorities, that a writer would be suspected of prejudice who spoke of them slightingly without adducing reason and evidence to prove them valueless; except, indeed, as records of the architectural practice, and the opinions and acquirements of an architect of a distant age. It is of very little consequence that Vitruvius is only known by his own writings, but that mention of him by a contemporary or other ancient author would probably determine the age in which he lived. From several things he mentions, and his inscription or dedication to the "Imperator Cæsar," it has been concluded that he lived in the time of Augustus; but certainly without sufficient reason; for if the man he speaks of as the son of Masinissa had been the son of the celebrated Numidian of that name, in the course of nature neither he nor Vitruvius could have lived to the time of Augustus. But he addresses an emperor who succeeded his father an emperor, and speaks of a temple of Augustus; so that he must have been a contemporary of some period of the empire. If that period had been the Augustan, he would doubtlessly have made some reference to some of the many distinguished men of that age, or have been referred to by some of them if he had himself been at all known or distinguished as his admirers insist he was; neither of which is the case; and, moreover, his language is not that of an educated man of the Augustan age. This, however, does not affect the merit of his work as a treatise on architecture; but his fables about the origin of building, the invention of the orders, and the arrangements which grew out of certain modes of construction, do so; by proving his total ignorance not only of the architectural works of the more ancient eastern nations, but of those of Greece itself, which he professes to describe. Now his classical taste, in consequence of his knowledge of antiquity, is vaunted by Perrault, one of his commentators, and given by him as a reason why Vitruvius was not much employed by the whimsical Romans in their love of variety, to which he would not administer. How far his knowledge of antiquity, that is, according to himself, of the works of the Greeks, extended, may be readily determined by comparing the designs of Greek structures, made by Perrault and others, according to the directions of Vitruvius, with the Greek structures

[1] *Cinquecento* means literally *five hundred*, but it is used as a contraction for *fifteen* hundred, or rather for *one thousand five hundred* by the omission of *mille*, the century in which the revival of architecture, of which we are about to speak, took place; and the manner consequent is so designated. *Trecento* would be *three* hundred, or the *third*, for the thirteenth century.

[2] *Le Fab. e i Disegni. di A. Palladio* da O. B. Scamozzi, tomo i. p. 4.

themselves as they exist at the present time, and are faithfully delineated in various modern works, but especially in Stuart and Revett's *Antiquities of Athens.* It is indeed not less strange than true, that not a single example of Greek architecture will bear out a single rule which Vitruvius prescribes, professedly on its authority; and not an existing edifice, or fragment of an edifice, in form or proportion, is in perfect accordance with any law of that author, nor indeed are they generally referable to the principles he lays down. Examples might be cited almost to infinity in support of this statement, and to prove the inutility of a work consisting of mere descriptions without delineations, even if it were otherwise correct. The latter may certainly be supplied from the ancient remains when they exist; but to a man in possession of the specimens, descriptions and directions for their composition are quite unnecessary. Even Sir William Chambers, a distinguished disciple of the Italian or Vitruvian school, speaks very lightly of the advantage to be gained from the study of the Vitruvian principles of construction; and Mr Gwilt, in the introductory treatises to and notes on Sir William Chambers's work, has done much to undermine the authority, by exposing the absurdities and fallacies of the Magnus Apollo of pseudo-classical architecture. A student would acquire as correct a knowledge of history and geography from the Seven Champions of Christendom and Gulliver's Travels, as of architecture from the text of Vitruvius!

The adoption of the Vitruvian laws by the Italian architects of the 15th century led to the formation of the "Five Orders." It will have been observed that, in speaking of the course of Greek and Roman architecture, the Doric, Ionic, and Corinthian styles were mentioned. Vitruvius describes, in addition to these, another, which he calls Tuscan—possibly a style of columnar arrangement peculiar to Italy, and most likely of Etrurian origin; but, in the absence of delineations, the *Cinquecentists* could only apply the proportions he laid down for it, to what appeared to approximate them in the ancient remains; and hence arose a fourth, or "the Tuscan Order." It is, however, a mere modification of the Roman debasement of the Doric, and may be considered, in its present form, as of purely modern Italian origin. The same "Revivers," on looking among the ruins of ancient Rome for the forms of their Vitruvian orders, found specimens of a foliated ordinance, which the bad taste of the Romans had compounded of the foliated and voluted styles of the Greeks. This was seized upon as a fifth style, subjected to certain rules and proportions, and called "the Composite Order." The very poor Roman specimens of Doric and Ionic fitted themselves without much difficulty to the Vitruvian laws; but the examples Rome afforded of the Corinthian were less tractable, and being as various as they are generally beautiful, they were all passed over, and their places supplied by a mere changeling—an epitome of the Vitruvian theory. Thus we have the "Five Orders" of the Italo-Vitruvian school, and in this manner they are arranged: *First*, the Tuscan, of which there is no recognised example of antiquity, but which owes its form to the descriptions of Vitruvius and the fancies of the revivers; *second*, the Doric, a poor and tasteless arrangement of the general features of the style on a Roman model; *third*, the Ionic, which is almost as great a debasement of the Grecian originals, and was produced in the same manner as the last-mentioned; *fourth*, the Corinthian, a something totally unlike the ancient examples of both Greece and Rome in beauty and spirit; and, *fifth*, the Composite, an inelegant variety of the Corinthian, or a hybrid mixture of the horned or angular-Ionic volutes, with a deep necking of the foliage of the preceding order.

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The first to publish this system was Leon Battista Alberti, a pupil of Brunelleschi. He has been followed by many others, the most distinguished of whom are, Palladio, Vignola, Scamozzi, Serlio, and De Lorme, architects; and Barbaro, a Venetian prelate, and an esteemed translator of, and commentator on, Vitruvius. None of these, it must be understood, agreed with any other of them, but each took his own view of the meaning of their common preceptor; and yet none of their productions evince the slightest approach to the elegance of form and beauty of proportion which distinguish the classic models of the columnar architecture of antiquity. Palladio and Serlio were the first to publish delineations and admeasurements of the Roman architectural remains in Italy; but the total absence of verisimilitude to the originals, and, in many cases, the absolute misrepresentations, in both works, prove how incompetent the authors were to appreciate their merits; and the exaggeration of their defects proves with equal clearness the general bad taste of the school in which they are masters. The worst qualities of the Roman school of architecture were embraced and perpetuated by the *Cinquecento.* The inharmonious and unpleasing combinations which arose out of the collocation of arches with columnar ordinances became the characteristics of the Italian: unequal intercolumniations, broken entablatures, and stylobates, enter alike into the productions of the best and of the worst of the *Cinquecento* architects. The style of this school is marked, too, by the constant attachment of columns and their accessories to the fronts or elevations of buildings; by the infrequency of their use in insulated (their natural) positions to form porticoes and colonnades; by the thinness or want of breadth in the smaller members of their entablatures, and the bad proportion of the larger parts, into which they are divided, to one another; by the general want of that degree of enrichment which fluting imparts to columns; by the too great projection of pilasters, and the inconsistent practice of diminishing, and sometimes fluting them; by the use of circular and twisted pediments, and the habit of making breaks in them to suit the broken ordinance they may crown; and by various other inconsistencies and deformities, which will be rendered more evident when we come to treat of the style in detail. The merit of the Italian school consists in the adaptation and collocation of the prolate hemispheroidal cupola, which appears to have grown out of its opposite in the Roman works during the Gothic ages, as we find it in the early cathedrals; though it is highly probable that the idea was brought from the East, in the forms exhibited by the cupolas of St Marks at Venice, and of Pisa cathedral. A very noble style of Palatial architecture also was practised by many of the Italian architects. It consists of the use of a grand crowning cornice, running in one unbroken line, unsurmounted by an attic, or any thing of the kind, superimposing a broad, lofty, and generally well-proportioned front, made into graceful compartments, but not storied, by massive blocking courses and other things, which are at the disposal of the judicious architect. Not unfrequently, however, the faults of the school interfere to injure a composition of this kind; for, to produce variety in the decorations of the windows, some of them have been made like doors, with distyle arrangements of columns, surmounted by alternations of circular and angular pediments, and sometimes with all the vagaries which deform the front of an Italian church. It is indeed the ecclesiastical architecture of the school in which its faults are most rife and its merits most rare. An Italian church possesses nothing of the stern simplicity and imposing grandeur of an Egyptian sacred structure—nothing of the harmonious

History. beauty and classic dignity of a Grecian fane—nothing of the ornate and attractive elegance of a Roman temple—and nothing truly of the glittering grace and captivating harmony of a Pointed cathedral. No other style of architecture presents so great a contrast, in any two species of its productions, as the Italian does, in one of its ordinary church fronts, with the front of a nobleman's mansion or palace, in the manner already referred to; and in no city of Italy is the contrast so strong, by the egregiousness of the examples it contains of both, as Rome. The stately portico is hardly known in Italian architecture; and in the rare cases which exist in it of insulated columns, they are for the most part so meagre in themselves, and so thinly set, according to the Vitruvian laws, that the effect produced by them is poor and wretched in the extreme. This applies most particularly to Italy itself: in some other countries, and especially in this, those architects who have been of the Italian school have generally preferred the proportions and arrangements which they found in the Roman examples of antiquity, to those laid down by their Italian masters. Still, Italian church architecture boasts the cupola,—certainly its redeeming feature; and the architects of Italy must have full credit for the use they have made of it, both internally and externally. Perhaps no two edifices display more, and in a greater degree, both the merits and defects of the school which produced them, than the Far-
Pl. LXIX. nese palace and the basilica of St Peter in Rome. The
and LXX. principal front of the former edifice is exquisite in its proportions, but frittered in its details. It has an immense crowning cornice, whose general effect is surpassingly grand; but the mouldings are too much projected, and its vertical parts want the breadth which the blocking courses possess. The lowest of its three tiers of windows is characterized by the most charming simplicity and good taste in almost every particular; but the other two are crowded with sins against both those qualities, in the dressings of the windows. The cortile and back front, though both very differently arranged from the front, and from each other, are not less filled with contrarieties; and so of the structure throughout. The front of St Peter's is not more distinguished by its magnitude than by its littleness and deformity. It contains the materials of a noble octaprostyle, and consists of an attached tetrastyle. It is divided into three unequal stories, within the height of the columns, whose entablature is surmounted by a windowed attic. In length it is frittered into a multitude of compartments, between which not the slightest harmony is maintained; while tawdriness and poverty are the distinguishing characteristics of its detail. A total absence of every thing which produces grandeur and beauty in architecture, marks, indeed, the whole of the exterior of the edifice, except the glorious cupola, than which architecture never produced a more noble and magnificent object. Internally, the structure is open to similar praise and similar dispraise. Gorgeousness in matter and meanness in manner characterize the interior of St Peter's, except the sublime concave which is formed by its redeeming feature without.

The *Cinquecento* architects of Italy were exceeding mannerists: but besides the manner of the school, each had his own peculiarities; so that there exists in their works what may almost be called monotonous variety! Brunelleschi's designs are distinguished by a degree of simplicity and comparative good taste, which cause regret that he had not referred more to the remains of antiquity in Italy, and sought out those of Greece, and less to the dogmas of Vitruvius; for then his works would have been more elegant than they are, and the school he founded would have done him much more honour than it does. The works of Bramante possess a more classical character than those of any other architect of the school. Bramante's design for St Peter's was preferred by Pope Julius II. to a great many others by the most esteemed men of the time. He it was who suggested the cupola; but, unfortunately, after his death men of less taste and talent were allowed to alter the design, and the edifice has resulted very differently from what it would have done had Bramante been adhered to. This we judge from his works generally, and not from any positive knowledge of the design, which indeed does not exist. The elder Sangallo was far inferior to his contemporary and rival Bramante, and his works are full of the faults of the school. Michel Angelo Buonaroti was a man of great genius, but of very bad taste in architecture; and to him may be attributed many of the bad qualities of the Italian style. His principal works are the buildings of the Capitol, and the College della Sapienza in Rome, and the Laurentian Library at Florence; and these are all distinguished for their singular want of architectural beauty and propriety in every particular. Michel Angelo was the Dante of Italian painting, but the Berni of its architecture. Raffaelle, too, had a very bad style in architecture, and so indeed had almost all the painters who professed to be architects also. They generally carried to extremes all the faults of the school. Sansovino and Sanmichele were men of considerable talent: their works display more originality and less servility than those of most of their contemporaries. Peruzzi was less employed than many who had not half his merit: his productions are with reason considered among the most classical of the Italian school. Vignola had a more correct taste than perhaps any other Italian architect of the 16th century: his works are indeed distinguishable by their superiority in harmony of composition and in general beauty of detail. Palladio very much affected the study of the antique, but his works do not indicate any appreciation of its beauties. He appears to have been very well qualified by nature for an architect, but spoiled by education. He did not look at the remains of antiquity with his own eyes, but with those of Vitruvius and Alberti, and of course was much influenced by the manner of the admired works of his predecessors. Palladio made greater use of insulated columns than the Italian architects generally, but his ordinances are deficient in every quality that produces beauty; his porticoes may be Vitruvian, but they certainly are not classic; and all his works evince that he studied the Colosseum, the Theatre of Marcellus, and the Triumphal Arches, more than the columns of Jupiter Stator and Mars Ultor, the Temple of Antoninus and Faustina, the Pantheon, the Portico at Assisi, and the other classic models, which he drew, but clearly did not appreciate. His columns upon columns, his attached and clustered columns, his stilted post-like columns, his broken entablatures, his numberless pilasters, straggling and unequal intercolumniations, inappropriate and inelegant ornaments, circular pediments and the like, are blemishes too numerous and too great to be passed over because of occasional elegance of proportion and beauty of detail. Scamozzi did not improve on the style of his master, which, however, he very much affected. Indeed the term *Palladian* has long been in general use throughout the civilized world for beautiful and excellent in architecture, so that it cannot be wondered at that Palladio's pupils and successors should imitate him; nor is it surprising that they did not surpass, or even equal him, for they were taught to look to his works as the *ne plus ultra* of excellence. Giacomo della Porta, a contemporary of Palladio, followed Michel Angelo in several of his works, and imbibed much of his manner, on which

he certainly improved; but still his own is far from being good. Della Porta was much employed in Rome; and it fell to him, in conjunction with Domenico Fontana, to put the cupola on St Peter's. Fontana's style of architecture is not particularly distinguished for its good or bad qualities; he obtained more reputation as an engineer than as an architect, having been engaged in removing and setting up most of the obelisks which give so much interest to the architectural scenery of Rome. The Lunghi, father, son, and grandson, the Rainaldi, Maderno, Borromini, Bernini, Carlo Fontana, Fuga, Vanvitelli, and many others in the course of the 17th and 18th centuries, carried the peculiarities of the Italian school to the greatest extremes. Of those enumerated, Bernini was perhaps the least offensive, and Borromini the most extravagant; but throughout that period, except in extreme cases, individual manner is less distinguishable, and that of the school more strongly marked.

It may be gathered from the preceding remarks, that the secular architecture of the Italian school is generally preferable to the ecclesiastical, and that the architects of the 15th and 16th centuries were generally superior to those who followed them. In Italy the school has not yet ceased to exist, nor indeed has its style ceased to be studied. Designs are still made by the students of the various academies in the manner of the *Cinquecento*, and on the models with which the country abounds. The precepts of Vitruvius are yet inculcated, and the works of the men whose names we have mentioned are looked up to as master-works of architecture in the country which contains the Roman Pantheon and the Greek Neptunium, besides the power of referring to the more exquisite works of Greece herself.

In the 15th century such was the reverence of men for the revived works of ancient literature and science, that the profession of the Italians, that they had restored ancient classical architecture on the precepts of an architect of the Augustan age, was sufficient to open the way for them all over civilized Europe. In the course of that and the following century Italian architecture was adopted and Italian architects employed in France, Spain, Germany, Great Britain, and their respective dependencies; and now, in the 19th century, Vitruvius and Palladio are as predominant on the shores of the Baltic as on those of the Mediterranean Sea; though in this country and in some parts of the Continent their influence is considerably diminished since the time of Inigo Jones and Claude Perrault. It has been already remarked, too, that the *Cinquecento* was later in gaining a footing here than on the Continent, in consequence of the existence of a beautiful national style of architecture, which our ancestors do not appear to have been induced to resign to the barbarian innovators of the South, as readily as the interjacent nations were to give up theirs; for which indeed the reason exists in the greater attractions of ours, and the consequent greater difficulty of inducing the nation to part with it. The French, though they received the Vitruvian architecture from the Italians, were patriotic enough, as soon as they had acquired its principles, to confine the practice of it almost entirely to native architects, in whose hands it assumed a different character from that which it possessed in Italy, and became what may be called the French style of *Cinquecento*. Its ecclesiastical structures are less faulty than are those of the corresponding period in Italy, but its secular edifices are as far inferior to those of that country. The grand palatial style, which is exemplified in the Farnese palace in Rome, never found its way into France; but instead, there arose that monstrous and peculiarly French manner, of which the well-known palaces of the Tuilleries and Luxembourg are egregious examples. In the age of Louis XIV. the French appear to have reverted to the Italian manner in a certain degree, for the palace of Versailles includes almost all the extravagancies of that school in its worst period, and contains moreover architectural deformities which Italy never equalled till it imitated them. They consist in the style of enrichment which is distinguished by the name of that monarch in whose reign it had its origin, and of whose gross taste and vulgar mind it is an apt emblem. The same period produced one of the most classical architects of the French school—its Palladio or Inigo Jones, Perrault, whose design for the buildings of the Louvre was preferred to that of Bernini, though indeed the preference was no compliment to the one nor discredit to the other, considering to whom the decision was of necessity referred. The Hôtel des Invalides is of the same age: it exhibits the graces of the Italian cupola, surmounting a composition which includes more than all the faults of St Peter's in Rome. The church of Sainte Genevieve, or the Pantheon, a work of the following reign, was intended to be in the ancient Roman style, and of Roman magnificence; but it is rather papally than imperially so. Ancient Rome was regarded in the columnar ordinance, but modern Rome in the architectural composition. In it the ecclesiastical style of the *Cinquecento* is commingled with the simple beauties of Roman architecture, almost indeed to the destruction of the latter: to this structure also there is a handsome cupola. Of late years the works of the ancients have been studied by the architects of France, greatly to the amelioration of their style; as yet, however, they are but imperfectly acquainted with the peculiarities of the Greek, and many of them still appear to retain their devotion to Vitruvius and the 15th century. Spain servilely received the Italo-Vitruvian architecture, and to the present day knows no other. Less patriotic than the French, the Spaniards have for their greatest works employed the architects of France and Italy; so that of course the country can boast of no peculiarity in the style of its architecture redounding to its own credit. The palace of the Escurial being by a French architect, and abounding in the deformities of the French and Italian schools, cannot be cited in favour of Spain. The Italian Revival was the means of extinguishing the Pointed style of architecture in Germany, and certainly without affording it an equivalent. Italian architects were employed in Germany, and Germans acquired their manner; but they did not improve it, nor did they make it productive of so many good effects as the Italians themselves did. The change in religion which supervened the change in architecture in so large a part of Germany, may have tended to prevent the latter from acquiring that degree of exuberance there which it did in Italy; but even in Catholic Germany the splendid Pointed cathedrals have never given way to modifications of the pseudo-classic St Peter's. In the use of *Cinquecento* architecture for secular structures, it may be truly said that the Germans have not excelled the Italians; nor, on the other hand, have they equalled them in the absurdities and extravagancies which are so frequently observable in the works of some of the latter. The Germans also have lately turned their attention to the works of the ancients, and the fruit of it is already evident in many parts of the country, and most particularly in Prussia: still, however, they appear to have yet to learn the right use of the Greek models, and a proper sense of the exquisite perfection of their detail; as well as to emancipate themselves from many of the trammels of the Vitruvian school. The northern continental nations have been dependent on Germany, France, or Italy for their architecture, and can produce nothing that gives them a claim to our consideration in such a review as the

History. present. St Petersburg is exclusively the work of architects of the nations just enumerated, and presents a mass of the merest common-places of Italian architecture, in structures calculated by their extent, like Versailles, the Escurial and St Peter's, to impose on the vulgar eye.

We have already more than once had occasion to refer incidentally to the introduction of *Cinquecento* architecture into Britain; and in noticing it more particularly, and tracing its course, we are saved the trouble of keeping up a distinction between the different parts of our triple nation, because, at the time it actually crossed the channel, the amalgamation of the kingdoms had taken place by the union of their crowns on the head of the Scotish sovereign.

English architecture. When the Pointed style received its deathblow in England, in the reign of Henry VIII., it did not immediately cease to exist; nor was it immediately succeeded by the Italian when it became extinct. It was gradually declining through all the 16th century, during the latter part of which period, what has been called the Elizabethan style became somewhat permanent. It consists of a singular admixture of the Italian orders, with many peculiarities of the Pointed style, and in many examples the latter appears predominant. With such difficulty, indeed, did that fascinating manner give up its hold on the minds of men in this country, that the *cinquecentists* appear to have relinquished the hope of effecting its destruction,—unfortunately, however, not until the injury was done; and for some time we were left without architecture of any kind, unless that may be called by the name which marks the edifices of the reign of James I., and of which the oldest parts of St James's palace are a specimen.

The destruction of the Pointed style has been referred by some to the change in religion which took place under the Tudor line of English monarchs; but such was certainly not the case. It was the "Reformation" of architecture in Italy, and not that of religion in Great Britain, that affected it; and it may be doubted whether the change would not have taken place sooner in this country, if its connection with Italy had not been so materially affected by the moral change here, and so delayed that of architecture; for it was Germany and France that supplied us with architectural reformers during the reigns of Henry VIII. and his children, and not Italy, whose professors might possibly have obtained more credit than their disciples did.

So dilatory were we, indeed, in the cultivation of the Italian style, that the first professor of it who was actually employed on edifices in this country came hither from Denmark! It is true, he was an Englishman; but so little hope did he appear to have of success at home, that he accepted an invitation from the king of that country, when he was at Venice, whither he had gone to study painting; but becoming enamoured of architecture, as he saw it in the works of Palladio, he had made that his study instead, and had already acquired considerable reputation in that city, when Christian IV. of Denmark invited him to his court to occupy the post of his first architect. A train of circumstances, to which we need not here advert, brought him to England a few years after James I. came to the English crown, and he was appointed architect at first to the queen, and subsequently to Henry prince of Wales. But he does not appear in consequence to have then obtained employment; for after the death of the prince, he went again to Italy, where he remained till the office of surveyor general, which had been promised him in reversion, fell vacant. This was the celebrated Inigo Jones, who has been called the English Palladio; and indeed he succeeded so well in acquiring the peculiar manner of that architect, that he richly deserves whatever credit the appellation conveys. It is unfortunate, however, for his own reputation, that he had not looked beyond Palladio and their common preceptor Vitruvius, to the models the latter pretends to describe; in which case he might have been the means of restoring, or at least of introducing, to his own country, the truly classical architecture of the ancients. But instead of that he brought nothing home but Italian rules and Italian prejudices. Jones commenced the truly Gothic custom of thrusting *Cinquecento* fittings into our Pointed cathedrals, by putting up an Italian screen in that of Winchester; and he barbarized the ancient cathedral of St Paul in London, by repairing it according to his notions of Pointed architecture, for it was in that style, and affixed to it an Italian front. Fortunately the great fire supervened, and made room for the present magnificent structure, by clearing away that early specimen of pseudo-classic taste. Of the Palladian style, however, it must be confessed Jones was a complete master. He designed a royal palace which was to have been built at Whitehall, in a manner as far superior to those of Versailles and the Escurial, as the works of Palladio are to those of Borromini. The only part of it ever executed is the structure called the Banqueting-House in London, whose exterior is an epitome of many of the faults, and most of the beauties, of the Palladian school. It rises boldly from the ground with a broad, simple, and nearly continuous basement or stereobate, and the various compartments of its principal front are beautifully proportioned; but the circular pediments to the windows, the attached unfluted columns, with broken entablatures and stylobates, the attic and balustrade, though they be the materials of Palladian, it may be confidently denied that they are consistent with classical architecture. Another well-known work of this architect is the Italo-Vitruvian Tuscan church of St Paul, Covent-Garden, whose eastern portico is well-proportioned in general, but grossly deformed in detail.

Architecture was in abeyance in this country, again, from the troublous times of Charles I. till the restoration of the monarchy in the person of his son, whose French taste would have completely Gallicized the architecture, as well as the manners and morals, of the nation, if the resplendent genius of Sir Christopher Wren had not been present to avert the infliction, or rather to modify it; for it cannot be denied that the influence of the French manner had an effect on the architecture of this country from that period down to the middle of the last century. Indeed Wren himself only knew the style he practised from books and the structures of France, except the few that existed of Inigo Jones in this country; and, in consequence of his visit to France, the peculiarities of the French style are obvious in many of his less esteemed works. Fortunately, however, he was proof against the grosser peculiarities of the *Cinquecento*, whether in the books of the Italians or in the edifices of the French; and his own productions evince that he had imbibed much of the spirit of the antique monuments of Italy, which he could have known only from engravings, and those very imperfect ones. The field that was opened to his genius by the great fire of London in 1666, and its result, are equally well known. It is true that the general offuscation of taste and feeling with regard to the Pointed style extended even to him. Wren was guilty of many offences in that respect, besides giving authority to the opprobrious term Gothic; and in no case more so than in the construction of the towers to Westminster Abbey, which are a lasting proof of his ignorance of its most obvious principles. Nevertheless, to the influence of our beautiful native style on his mind, architecture is indebted for some of its most charming works. If Wren had not been accustomed to contemplate the graceful and elegant pyramids or spires of his native country, he would never

have originated the tapering steeple, in the composition of which with the materials of Italian architecture he still stands as unrivalled as he was original. Witness the steeples of Bow Church and St Bride's in London, the former of which is hardly surpassed in grace and elegance by the Pointed spires themselves. It must remain a constant subject of regret that this great head of the English school of *Cinquecento* architecture did not know the remains of ancient Greece and Rome from personal observation. With his splendid genius and fine taste, if he had not been imposed on by the specious pretence of the Italo-Vitruvian school, his works would have been models for imitation and study, as they are objects of admiration: as it was, he avoided many of the faults of that school, and improved on many of its beauties. Without knowing the Greek style at all, and knowing the Roman only through imperfect mediums; without, indeed, ever having seen an example of either; whenever he has varied from the Italian practice, it has been towards the proportions and peculiarities of the Greek! The great west front of St Paul's, though it is said to be imitated from that of St Peter's in Rome, or rather from what it was proposed to be, with the two towers to form its wings, is a much finer, a more imposing, and more classical specimen of architecture than its prototype; for the advantage the latter should have in being of columns in one height is lost entirely in their poverty and the miserable arrangement of the whole front; whereas that of St Paul's is in two noble pseudo-prostyle and recessed porticoes, with the columns fluted, and generally conceived and executed in much better taste than those of the former. The entablatures, though massive, are finely proportioned, and sufficiently ornate to be elegant; they are, too, quite continuous, and the upper one is surmounted by a noble pediment, whose pyramidal form gives at the same time dignity and a finished appearance to the whole front. The coupling of the columns, however, and the putting of one columnar ordinance over another, can only be defended by the practice of the Italian school; though, in the present case, both are rendered less offensive by the judicious management of the architect. Nothing shows more strikingly the superiority of St Paul's to St Peter's, as an architectural composition, than a parallel of their flanks. The great magnitude of the latter may strike the vulgar eye with admiration in the contrast; but the rudest taste must appreciate the surpassing merit of the former in the form and arrangement of the cupola, and the noble peristyle with its unbroken entablature and stylobate, out of which it rises, when compared with the sharper form and depressed substructure of that of St Peter's. The superiority of St Paul's in the composition of the main body of the edifice is not less in degree, though perhaps less obvious, than in the superstructure. In the one it is broken and frittered, and in the other almost perfectly continuous, in broad, bold, and effective masses.

The history of the works of Sir Christopher Wren is the history of the architecture of the period in this country; and as it must be admitted that he was not so successful in the composition of the architecture of secular structures as of ecclesiastical, it will follow that our secular edifices of that time are of inferior merit. If it were not indeed an historical fact, it would hardly be credited, that Chelsea College, the old College of Physicians in London, and the halls of some of the city companies, are by the architect of Bow Church and St Paul's.

The style introduced by Sir John Vanbrugh, who may be said to have succeeded Sir Christopher Wren in the direction of architecture in England, was distinguished by massiveness unsuited to the style in which he built, which was of course Italian. It was, however, free from the vagaries and extravagancies which characterize that style generally in other countries at the same period, but was certainly more suited to the soberer character of ecclesiastical than of secular structures, whereas his principal works were noblemen's mansions. Vanbrugh's faults were generally those of Michel Angelo: he was a painter's architect, and did not understand beauty of proportion and detail so well as the pictorial arrangement of lights and shadows; to produce which in the *Cinquecento* it is almost necessary to part with all the higher beauties of architecture. Hawksmoor added to the style of his master that noble ornament in which Italian works are so very deficient —a prostyle portico. His compositions are marked by severe simplicity, and only want to be absolved from a few faults and enriched with a few elegancies to be among the best of modern times. Not the least distinguished architect of the same age (the first half of the 18th century) was the Earl of Burlington, who was a passionate admirer of the style of Palladio and Inigo Jones. Many of the edifices erected by Kent are believed to be from the designs of that amiable nobleman, who, with considerable talent, was, however, a somewhat bigoted devotee to Vitruvius and the *Cinquecento* generally, as well as to Palladio in particular; for he has frequently used columns representing half-barked trees, in conformity with the silly tales of Vitruvius, and the sillier whims of his disciples. The portal of his own house in Piccadilly, and that of the King's Mews, are special examples of this bad taste, and of other faults of the school besides. Lord Burlington built for himself at Chiswick a villa on the model of the Villa Capra, or Rotonda, near Vicenza—a structure which has been called the masterpiece of Palladio. In form and proportion it is certainly elegant, but its details strongly exhibit the poverty of Italian columnar architecture, when unaided by the frittering which is its bane, and almost its sole dependence for effect. Gibbs was a contemporary of the same period. He too, like Hawksmoor, had imbibed a taste for the classic prostyle portico, which he evinced in St Martin's church in London; but that he also was in the trammels of the Italian school is no less evident, in the same structure, to a considerable extent, and still more so in the church of St Mary in the Strand, which is a bad specimen of architecture, and a favourable one of its style. During the following half-century (the latter half of the 18th) Sir William Chambers and Sir Robert Taylor were the most distinguished architects of this country. They were both men of talent and genius, who had availed themselves of the remains of Roman antiquity to good purpose; for as yet those of Greece were either unknown or unappreciated; and the former of them has left us, in the Strand front of Somerset House in London, perhaps the best specimen of its style in existence. Other parts of the same edifice, however, are far from deserving the same degree of praise: indeed, as an architectural composition, the river front is altogether inferior in merit to the other, though of much greater pretence. The inner fronts to the great quadrangle, though exhibiting good parts, are, as a whole, not above mediocrity. An air of littleness pervades them; and the general effect of the fronts themselves is made still worse by the little clock towers and cupolas by which they are surmounted; and to this may be added the infinity of ill-arranged chimneys, which impart an air of meanness and confusion that nothing can excuse. While Sir William Chambers and a few others were applying the best qualities of Italian architecture, indeed improving its general character, and, it may be said, making an English style of it, there were many structures raised in various parts of the country in a manner hardly superior to that of the time of James I.; structures in which all the meanness and poverty of the

History. *Cinquecento* are put forth, without any of its elegance of proportion, or that degree of effectiveness which men of talent contrived to give it. During the same period, too, the seeds of a revolution were sown, which has almost succeeded in ejecting the Italian style and its derivative from this country, without perhaps having as yet furnished a complete equivalent.

In the year 1748 James Stuart and Nicholas Revett, two painters pursuing their studies in Rome, having moreover paid some attention to architecture, issued "Proposals for publishing an accurate description of the Antiquities of Athens, &c." These proposals met with general approbation, and in consequence they determined on prosecuting their plan; but various hinderances prevented their arrival in Athens till March 1751, when they commenced measuring and delineating the architectural monuments of that city and its environs. In this work Messrs Stuart and Revett were unremittingly employed (as far as their own exertions went, for they were frequently interrupted by the Turks) for several years, so that they did not reach England with the result of their labours until 1755; and, by a series of almost unaccountable delays, the first volume of their work did not appear until the year 1762. Sixteen years more expired before the second issued from the press; and the third was not published until 1794, being nearly fifty years from the time the work was first announced! Avarice and envy had induced a Frenchman of the name of Le Roy, who was at Rome when our countrymen issued their proposals, to forestall them with the public, and rob them of the profit and reputation they were so hardly labouring to earn. This man went to Athens, and in a very short time collected some loose materials, with which he published at Paris, in 1758, a work which he called *Les Ruines des plus beaux Monumens de la Grèce, &c.*, in which he makes not the slightest mention of Stuart and Revett, nor of their labours or intentions, with all of which he was well acquainted. This work is moreover notoriously and grossly incorrect; so incorrect indeed, as to make it difficult of belief that its author ever saw the objects of which he professes to give the representations. Such as it is, however, it was from M. le Roy's work that the public had to judge of the merits and beauties of Greek architecture; for we have said that the first volume of Stuart and Revett's did not appear for several years after it, and that does not contain any pure specimen of the national or Doric style: the second, which does, was not published for twenty years after Le Roy's. Considering, therefore, the source from which the public had to derive information on the subject, it can hardly be wondered at that Greek architecture was vituperated on all sides; and by none with greater acrimony than by Sir William Chambers, whose apology must be, ignorance and the prejudices of education. He really did not know the style he carped at; and his education in the Italo-Vitruvian school had unfitted him for appreciating its grand, chaste, and simple beauties, even if he had known it. Notwithstanding the misrepresentations of Le Roy, the vituperations of Chambers, the established reputation of Italian architecture, and the trammels which Vitruvius and his disciples had fixed on the public mind, when Stuart and Revett's work actually appeared, the Greek style gradually advanced in esteem, by dint of superior merit alone—for it has had no factitious aids; and since that period Greece and all her colonies which possess remains of her unrivalled architecture have been explored, and we now possess correct delineations of almost every Greek structure which has survived, though in ruins, the wreck of time and the desolation of barbarism. To our country and nation, then, is due the honour of opening the temple of Greek architectural science,—of drawing away the veil of ignorance which obscured the beauties it contains,—and of snatching from perdition, and consequent oblivion, the noble relics of ancient architecture which bear the impress of the Grecian mind. Not only indeed were we the first to open the mine, but by us it has been principally worked; for among the numerous publications which now exist on the Hellenic remains, by far the greatest number, and indisputably the most correct, are by our countrymen, and were brought out in this country. It required, however, a generation for the effects of ignorance and prejudice in some, and imperfect knowledge in others, to wear away, before the beneficial effects of the Greek style could be obvious in our structures. The works of the Adamses, who were contemporaries of and immediate successors to Sir William Chambers, evince a taste for the beauties of Greek architecture, but a very imperfect knowledge indeed of the means of reproducing them. The architects who have had the direction of our principal works during the first quarter of this century had the disadvantage of being pupils of those who were themselves, as we have shown, incompetent to appreciate the Greek style; and at a time too when the state of Europe shut up all access to the remains of Greece and Rome; so that no great improvement could perhaps be expected from them. When they shall have passed away, it is to be hoped that we shall find a new class, some of whom, indeed, are already before the world, who, having received their education since peace has opened the Continent, are prepared by the actual contemplation and study of the works of Egypt, Greece, Rome, and Italy, in all their varieties, to form new and pleasing combinations of their beauties, adapted to our wants,—to produce what may equal, if not surpass them all. The structures of Egypt may show how to arrange large masses harmoniously and effectively; those of Greece and Rome how to impart grace and dignity; and the structures of Italy how the materials of ancient architecture may be moulded to modern uses, while at the same time they give practical warning of what may result from the abuse of the most obvious principles of the science.

The difference between the representations of the Athenian antiquities by Stuart and his colleague, and the misrepresentations of them by Le Roy, appear to have opened the eyes of the world to those of ancient Rome, to see if they too had not been dealt with unjustly; for of late years much more correct delineations of them have appeared than those of Palladio and Desgodetz,—delineations of them as they exist, exhibiting the spirit of the originals, and not warped to the Vitruvian precepts, and thereby stripped of their best quality, truth. The excavation of the ancient cities of Herculaneum and Pompeii has opened to us much interesting matter, and some that is instructive: their ruins too have the advantage of being correctly delineated; so that we are at this time in possession of more knowledge of the architecture of the ancients, acquired in a few years by the actual examination of its relics, than our predecessors of the last generation were, after talking, and writing, and reading Vitruvius about it, for nearly four centuries.

It is an argument in proof of the classical beauty of the Pointed style, that when the eyes of men were opened to the perfections of Greek architecture, they began to discover its merits also. Pointed architecture, under the opprobrious name Gothic, had long been a subject of discussion among antiquaries; that is, essays were written by them to prove how the Pointed arch originated, but none appreciated its beauties. Our Pointed cathedrals and churches were, after the example of Inigo Jones, ruth-

lessly barbarized in repairing and fitting up. If an architect were employed to do any thing in or to one of them, he appears to have thought it incumbent on him to convert it to the doctrines of his own faith—to Italicize it. Deans and chapters for the most part intrusted their commissions to country masons and plasterers, who also operated according to the laws of the "five orders." About the middle of the 18th century one Batty Langley endeavoured to draw the attention of the world to Pointed architecture, by reducing it to rules, and dividing it into orders. Fortunately he was only laughed at, and both he and the book he published on the subject were soon forgotten. One of the first men in rank and influence of his time, in matters of taste particularly, Horace Walpole, *patronized* Pointed architecture, but ineffectually. He had himself neither taste nor feeling to appreciate its beauties, as his Strawberry Hill clearly evinces; so that his patronage of it must have been the effect of mere whim, or a wish to lead a fashion. Delineations were indeed put forth from time to time, but generally so rude and imperfect, that, like M. le Roy to Greek architecture, they did more harm than good. The Society of Antiquaries, however, at length took up the subject, engaged Mr John Carter, an ardent and judicious admirer of our national architecture, and commenced the publication of a series of splendid volumes, containing engravings of its best specimens, from drawings and admeasurements by him. The "Antiquities of Athens" had already done much to dispossess men of their prejudices, by showing that Greek architecture, though neither Vitruvian nor Palladian, was nevertheless beautiful; and the great work of the Society of Antiquaries did the same for Pointed architecture. Since the death of Mr Carter, our native style has been beautifully illustrated, in a series of valuable works by Mr Britton, and elucidated in detailed "specimens," by Mr Pugin, a French gentleman but an English artist, and by a great variety of other useful and excellent publications; so that, at the present time, the Pointed style, too, is studied and understood, and not a few of our architects are now competent, not only to be intrusted with the repairs and restorations of the ancient structures, but also to originate new ones, which may rival all but their prototypes in beauty.

We have now, in this part of the subject, only to add a few remarks on the improvement which has taken place in domestic architecture, since men have begun to consider their own comfort and happiness of as much importance to them as the splendour of their religious edifices. The exhumated city of Pompeii has very clearly proved, that notwithstanding the extent and general beauty of the public buildings of the Romans, the houses of the commonalty were exceedingly plain and confined, while those of the higher classes, though internally elegant, were externally unpretending. The rooms were small and badly arranged, imperfectly secluded from the public gaze, and quite exposed to the inmates; pervious alike to the summer's heat and winter's cold. Indeed, the house of a Roman gentleman presents a very convenient model for a prison, but without many of the comforts which in modern times are thought necessary even in such places. Of this, however, we shall treat more in detail when we come to consider Roman architecture as a style. It has been stated as probable, that the use of wooden floors, and the consequent power of making additional stories without enormously thick walls, arose during the middle ages. That improvement, together with the use of glass for windows, gives an air of comfort and convenience to the earliest domestic structures of modern times, of which the ancients could have had no idea; but the latter were deficient in elegance, though indeed the use of windows tended to the introduction of external architectural decoration. With learning and civilization came refinement and luxury, and men began, though at a great distance, to imitate in their houses what they found of beautiful and splendid in the churches and monasteries. The exclusion, by glass windows, of currents of cold air, which carried the smoke off to the funnel in the roof of a hall or large room, when the fire was exposed in the middle of it, led to the invention and use of chimneys, which should convey it away without occupying the room at all. This is more particularly applicable to the colder countries north of the Alps, and it is in them that domestic building is best understood, and is best applied to produce comfort and convenience. Not that the *Palazzi* of Italy are not generally more pretending in their external architecture than the town mansions of this country; but they are deficient in those internal arrangements which tend to produce the greatest possible advantages, which, indeed, promote the enjoyments of domestic life.

In consequence of the refinements which now pervade the manners, habits, and customs of civilized life, and civilization having extended itself from the noble and the learned through almost the whole social system, men are no longer contented to admire the beauty and magnificence of public edifices, whether ecclesiastical or civil, and to witness the splendour and elegance of the palaces and mansions of the wealthy; but all are anxious to see in their own habitations that degree of decoration and beauty which they find so productive of pleasure and pleasurable emotions. Thus architecture is no longer confined to the temples of the divinity and the palaces of the great, but its beauties are sought everywhere. In every edifice whose inhabitant has been fitted by education and habit to appreciate and enjoy the charm which arises from symmetry of form, beauty of proportion, and elegance of detail, the aid of architecture is required.

Of Egyptian Structures.

The architecture of ancient Egypt is characterized by the boldness and magnitude of its parts, and the almost monotonous uniformity which pervades its features. The existing monuments of Egyptian architecture consist for the most part of temples and pyramids. Obelisks are generally found in connection with the former, so that perhaps they can only be considered as belonging to them, and not as distinct architectural works, or the sphinxes and other things of a similar nature must be considered as such also. Neither can the hypogea or excavations be correctly described as belonging to architecture, though they bear many of its features, and were perhaps the antitypes of regular architectural combinations.

The pyramids are almost solid masses of masonry, whose bases are squares, and whose inclined sides are nearly equilateral triangles: some of them are truncated, and some run up to a point. They are generally much injured on the surface by long exposure, so that it is impossible to say whether any of them were considered finished while in steps or receding courses, or if the angles were either filled up or worked off, to make smooth surfaces on the exterior. Some of them not only were made plain by working off, but remain so still; whilst others bear no indication of ever having been finished in that manner. In one existing example, that of the great southern pyramid of Dashour, the angles of the receding courses have been wrought off; and it is singular that the blocks of stone are not laid in horizontal courses, but at an angle inclined to the base; nor are its sides carried up to the top in one continued plane, but at about two thirds from the base they incline towards each other under a more obtuse angle.

It has been imagined, but not determined, that most of

Egyptian Structures.

them have natural hills, either of earth or stone, for cores, or rather that hills have been cut to the shape, and built over with large courses of stone to give them the appearance of being solid masonry. If this be the case, the chambers and the passages to them, which have been discovered in some of the pyramids, have been carefully built around to have the appearance of being left in the construction, which is not very probable. Another suggestion, to account in some measure for the immense quantity of matter in them, is, that they are actually cut in living rock to a considerable height, and built above. This may be the case with regard to those which are of the stone the place affords; but some of them are of foreign material, externally at least, and of consequence cannot have been hewn in the native rock. More consistent with the genius of Egyptian undertakings, but hardly more probable is it, that the pyramids include or cover some such constructions as the labyrinth beyond Lake Mœris, spoken of by Herodotus, according to the suggestion we have made in another place, or chambers of some kind which may have been the depositories of the arcana of Egyptian learning and science. Such indeed is the immense extent of some of these extraordinary monuments of human industry and human folly, that no suggestion with regard to them can be considered wild, as they afford full scope for the imagination, without presenting any thing to support or refute any theory that may be applied to them.

The Egyptian temples, without possessing that entire uniformity of plan which those of the Greeks do, are very similar in arrangement and manner. The larger and more perfect structures do not externally present the appearance of being columned, a boundary wall or peribolus girding the whole, and preventing the view of any part of the interior, except perhaps the towering magnificence of some inner pylones; of the lofty tops of an extraordinary avenue of columns, with their superimposed terrace; of the tapering obelisks which occupy, at times, some of the courts; or of a dense mass of structure, which is the body of the temple itself, inclosing the thickly columned halls. The immense magnitude of these edifices may perhaps have made them independent, in their perfect state, of considerations which have weight in architectural composition at the present time, and on which indeed its harmony depends. The various portions of the same temple differ in size and proportion; and being intermingled, the cornices of the lower abut indefinitely against the walls of the higher parts, while the latter are not at all in accordance among themselves.

Pl. LVI.

The structure we produce to exemplify Egyptian architecture, though not, according to Mr Champollion, one of the Pharaonic monuments, is perfectly characteristic of the style and arrangement of Egyptian temples, and is a more regular specimen than any other possessing the national peculiarities. It is known as the temple of Apollinopolis Magna, or of Edfou, in Upper Egypt, on the banks of the Nile, between Thebes and the first cataracts.

The plan of the inclosure behind the propylæa is a long parallelogram, the moles or propylæa themselves forming another across one of its ends. The grand entrance to the great court of the temple is by a doorway between the moles, to which there may have been folding gates, as the notches for their hinges are still to be seen. Small chambers, right and left of the entrance, and in the core of the propylæa, were probably for the porters or guards of the temple: a staircase remains on each side, which leads to other chambers at different heights. To furnish these with light and air, loop-holes have been cut through the external walls, which disfigure the front of the structure. The court-yard, cloister, or vestibule, has on three of its sides a colonnade, against the wall of the peribolus, forming a covered gallery. This, and the gradual ascent by corded steps to the great portico or pronaos, will be better understood by reference to the plan and section. The pronaos, or covered portico, consists of three rows of six columns each, parallel and equidistant, except in the middle, where the intercolumniation is greater, because of the passage through. The front row of columns is closed by a sort of breast-work or dado, extending to nearly half their height, in which moreover they are half-imbedded; and in the central opening a peculiar doorway is formed, consisting of piers, with the lintel and cornice over them cut through, as exhibited in the elevation of the portico. From the pronaos another doorway leads to an atrium or inner vestibule, consisting of three rows of smaller columns, with four in each, distributed as those of the pronaos are. Beyond this vestibule there are sundry close rooms and cells, with passages and staircases, whose intention is not obvious. The insulated chamber within the sixth door was most probably the adytum or sanctuary, the holy of holies, which was honoured by the presence of the divinity: the rest is inexplicable.

In many cases the temples are without the peribolus and propylæa, the edifice consisting of no more than the pronaos and the parts beyond it; and in others, particularly in those of Thebes, this arrangement is doubled, and there are two pairs of the colossal moles, the second being placed where the pronaos is in this, and another open court or second vestibule intervening them and the portico. In these the central line across the courts is formed by a covered avenue of columns, of much larger size than ordinary; and the galleries around are of double rows of columns instead of one row with the walls, as in this case. The obelisks marked in the plan, and indicated in the section, before the propylæa, occupy the situation in which they are generally found, though they do not exist with this example. Colossal sedent figures are sometimes found before the piers of the gateway; and from them, as a base, a long avenue of sphinxes is frequently found ranged like an alley or avenue of trees from a mansion to the park-gate, straight or winding, as the case may require.

The longitudinal section of the edifice shows the relative heights of the various parts, and the mode of constructing the soffits or ceilings, which are of the same material of which the walls and columnar ordinances are composed: this is in some cases granite, and in others freestone. The elevation of the pronaos shows also a transverse section of the colonnades and peribolus. It displays most of the general features of Egyptian columnar architecture; the unbroken continuity of outline, the pyramidal tendency of the composition, and the boldness and breadth of every part. The good taste with which the interspaces of the columns are covered may be remarked. Panels standing between the columns would have had a very ill effect, both internally and externally; and if a continued screen had been made, the effect would be still worse, as the columns must then have appeared from the outside absurdly short; but as it is, their height is perfectly obvious, and their form is rendered clear by the contrast of light and shade occasioned by the projection of the panels, which would not exist if they had been detailed between the columns. The lotus ornament at the foot of the panels is particularly simple and elegant; and nothing can be more graceful and effective than the cyma above their cornice, which is singularly enriched with ibis mummy-cases. The jambs forming a false doorway in the central interspace, are a blemish in the composition; and they injure it very much by the abruptness of their form, and their want of harmony with any thing else in it. It may be remarked, that the effect of the front generally is that

of an excavation rather than of a structure, the end piers and entablature having a unity of purpose, which leads to the idea that the rest was similar, or the whole at first a plain wall afterwards pierced and carved into its present form. This view of it would support the supposition that the excavations or hypogea are the antitypes of columnar architecture.

The front elevation of the moles or propylæa, with the grand entrance between them, is peculiarly Egyptian; and very little variety is discoverable between the earliest and latest specimens of this species of structure. It is an object that must be seen to be appreciated; simplicity and an inherent impressiveness in the pyramidal tendency are all on which it has to depend for effect, except magnitude, which alone would certainly make no agreeable impression on the mind. The projecting fillet and coving which form a cornice to the structures, though large and bold, appear small and inefficient when compared with the bulk they crown; and there is nothing particularly striking in the torus which marks the lateral outline and separates the straight line of the front from the circular of the cornice. Neither are they dependent for their effect on the sculpture, for their appearance is as impressive at such a distance as to make the latter indistinct, as near, if not more so. The effect of the sculptures and hieroglyphics generally on Egyptian architecture is to enrich the surfaces, but not to interfere with the general form of a structure, or even with those of its minor parts.

A portion of the portico is given on a larger scale, to show more clearly the forms and arrangement of Egyptian columnar composition. The shaft of the column in this example is perfectly cylindrical. It rests on a square step, or continued stylobate, without the intervention of a plinth or base of any kind; and has no regular vertical channelling or enrichment, such as fluting, but is marked horizontally with series of grooves, and inscribed with hieroglyphics. The capitals are of different sizes and forms in the same ordinance. This example is about one diameter of the column in height, exclusive of its receding abacus. Its outline is that of the cyma, with a reversed ovalo fillet above, and its enrichment consists principally of lotus flowers. The capital of the column next to this, in the front line, is much taller, differently formed, and ornamented with palm leaves; the third is of the same size and outline as the first, but differently ornamented; and the corresponding columns on the other side of the centre have capitals corresponding with these, each to its fellow, in the arrangement. Above the capital there is a square block or receding abacus, which has the effect of a deepening of the entablature, instead of a covering of the columns when the capitals spread, as in this case. In the earlier Egyptian examples, however, in which the columns are swollen, and diminished in two unequal lengths, the result is different, and the form and size of the abacus appear perfectly consistent. The height of this column and its capital, without the abacus, is six diameters. The entablature consists of an architrave and cornice, there being no equivalent for the frieze of a Greek entablature, unless the coving be so considered, in which case the cornice becomes a mere shelf. The architrave, including the torus, is about three quarters of a diameter in height, which is half that of the whole entablature. The architrave itself is in this example sculptured in low relief, but otherwise plain. The torus, which returns and runs down the angles of the building, is gracefully banded, something like the manner in which the fasces are represented in Roman works. The coving is divided into compartments by vertical flutes, which have been thought to be the origin of triglyphs in a Doric frieze; but these are arranged without reference to the columns, and are in other respects so totally different from them as to give but little weight to the opinion. The compartments are beautifully enriched with hieroglyphics, except in the centre, where a winged globe is sculptured, surmounting another on the architrave, as shown in the elevation of the pronaos. The crowning tablet or fillet is quite plain and unornamented. Angular roofs are unknown in ancient Egyptian buildings, and consequently pediments are unknown in its architecture.

Hindoo Structures.

Of the style of architecture used in the domestic edifices of the Egyptians we can give no idea, as no documents remain by which it may be known; neither can we judge of it by analogy from what we know of that of other nations of antiquity, for no direct analogy exists between the styles of their mutually existing structures. Indeed the Romans are the only people, above the Christian era, of whose domestic architecture we know any thing with certainty; and the advantages they possessed over their predecessors in their knowledge of the use of the arch was so great, for that purpose especially, that theirs affords no ratio for that of the Greeks even, and still less for that of the Egyptians.

Of Hindoo Structures.

From local circumstances, structures in India are exposed to rapid destruction as soon as they lose the protecting power of man; and thus the absence of any positive architectural works in that country which can be determined to be of high antiquity may be partly accounted for. But religious intolerance and devastating war have conspired together to aid natural causes in the destruction of the ancient edifices of the Hindoos. Whatever of antiquity fell in the route of that ruthless conqueror Mahmood of Ghizni, in his twelve expeditions into India, was defaced or destroyed; and those structures in the more remote parts, impervious to his march, either want data to pronounce on their antiquity, or, when they possess any, it is in a character still unintelligible to the learned. But there are some to which tradition—and this we should not altogether reject—assigns a date beyond the age of Alexander; and we understand that the unity of style of these warrants the assumption of immense priority for them to all now existing in Gangetic India. It is from Rajpootana that we may yet look for developments of the ancient architecture of the Hindoos; a field of great magnitude, only just begun to be explored, and still remaining undelineated. Extensive excavations, however, of much greater magnitude even than those of Egypt, and, it is presumed, of at least equal antiquity, are found in various parts of India; and they may be supposed to bear some resemblance to their contemporaneous structures, of which, most likely, they were either the representations or the originals. But we thus arrive only at the style: the composition and arrangement of structures cannot be deduced from the hypogea; for though these latter in Egypt agree in style with the architecture, they would not suggest the other particulars.

The most common Hindoo pagoda of the present day is composed of a rectangular mass, surmounted by a graduated truncate pyramid. That this species of structure is of very considerable antiquity, may be concluded from the fact, that every thing in its composition and arrangement is determined by immutable precepts of a religious nature. This was ascertained by Colonel Tod, the learned annalist of Central India, from a man to whom the precept had descended with his profession from his ancestors through more than forty generations.

These kinds of evidence, however, though interesting, are not conclusive; and we must consent, for the present at least, to remain in ignorance of the Hindoo archi-

Grecian Structures.

tecture of the early ages, to which our inquiry is more immediately directed. The splendid works of the Moslem conquerors of that country bear no relation whatever to its indigenous architecture.

Of Grecian Structures.

As no nation has ever equalled the Egyptians in the extent and magnitude of their architectural monuments, neither have the Greeks been surpassed in the exquisite beauty of form and proportion which theirs possess. Extreme simplicity and perfect harmony pervade every part of a Greek structure; and to the evanescence of the finer spirit of these qualities may be referred the difficulty—for great difficulty certainly exists—of applying Grecian architecture to modern practice. The national style, or Doric Order, is in every respect the most distinguished and the most intractable. The voluted Ionic being more complicated, is more plastic; and the foliated Corinthian, from its still greater divergence from Doric simplicity and harmony, is the most easily moulded to various purposes. Unfortunately nothing remains from which we might acquire a knowledge of the practice of the Greeks themselves in the architecture of domestic and general structures; but it may be inferred from some existing edifices, particularly the Choragic monuments, that the Doric columnar style was not used by them except for the temples of the gods and some of their accessories. But whether this arose—if the feeling really did exist—from the sanctity of its character, in consequence of that appropriation, or from the difficulty of moulding it to general purposes, cannot be determined. It is very certain, however, that the few structures which do exist of Greek origin, not of a religious character, are either Ionic or Corinthian, or a mixture of one of them with some of the features of the Doric; and in all Greece and the Grecian colonies, except Ionia, there are very few examples of religious edifices not of the Doric order, and none which are of the Corinthian.

We have already given our reasons for mistrusting the descriptions of ancient writers on architectural subjects; and when they merely make reference to different parts of a structure, without pretending to describe, in the absence of examples or models they must be unintelligible, and therefore no more valuable to the architectural antiquary than those of the others, whom existing specimens of what they profess to describe prove to have been totally ignorant of their subject. We shall therefore not attempt to develope what does not exist, either from inferences to be drawn from Homer and others, from the professional dicta of Vitruvius, or from the description of Pausanias; but confine ourselves to the remains of the architecture itself of the Greeks, which are actually before our eyes, for the elucidation and exemplification of the Grecian style.

Like the architecture of Egypt, that of Greece is known to us principally by means of its sacred monuments, and from them is deduced almost all we know of its principles. The Doric temples of the Greeks are uniform in plan, and differ only in arrangement and proportion, as they are of greater or less size; for every part depends on the same thing. If the dimensions of a single column, and the proportion the entablature shall bear to it, were given to two individuals acquainted with the style, with directions to compose a hexastyle peripteral temple, or one of any other description, they would produce designs exactly similar in size, arrangement, features, and general proportions, differing only, if at all, in the relative proportions of minor parts, and slightly perhaps in the contour of some of the mouldings. This can only be the case with the Doric, and it arises from the intercolumniation being determined by the arrangement of the frieze with triglyphs and metopes; the frieze bearing a certain proportion in the entablature to the diameter of the column, and so on, in such a manner that the most perfect harmony is preserved between every part. Thus, in the example, the column is so many of its diameters in height; it diminishes gradually from the base upwards, with a slightly convexed tendency or swelling downwards; and is superimposed by a capital proportioned to it, and coming within its height. The entablature is so many diameters high also, and is divided, according to slightly varying proportions, into three parts—architrave, frieze, and cornice. A triglyph bearing a certain proportion to the diameter of the column is drawn immediately over its centre; the metope is then set off equal to the height of the frieze; another triglyph is drawn, which hangs over the void; then a metope as before; and a second triglyph, the centre of which is the central line for another column; and so on to the number required, which, in a front, will be four, six, eight, or ten columns, as the case may be, the temple being tetrastyle, hexastyle, octastyle, or decastyle; and on the flanks twice the number of those on the front and one more, counting the columns on the angles both ways. Thus a hexastyle temple will have thirteen columns on each flank, an octastyle seventeen, and so on. It must be observed, however, that to ease the columns at the angles, they are not placed so that the triglyph over them shall impend their centre as the others, but are set in towards the next columns so far that a line let fall from the outer edge of the triglyph will touch the circumferential line of the column at the base, or at its greatest diameter. It has been generally thought that the object in this disposition was to bring the triglyph to the extreme angle, to obviate the necessity of a half-metope there; and many imitators have puzzled themselves to no avail to effect it, without contracting the intercolumniation or elongating the first metope; though it is perfectly obvious that the intention of the Greek architects was to ease the columns in those important situations of a part of their burden, and for no such purpose as Vitruvius and his disciples have thought. Indeed, this has been a problem to the whole school, which their master proposed, and which they have settled only by putting a half-metope beyond the outer triglyph; thus preserving the intercolumniation equal, but rendering the angles more infirm, or perhaps less stable, than the Greek architects judiciously thought they should be. Besides contracting the intercolumniation, the Greeks also made the corner columns a little larger than the rest, thus counteracting in every way the danger that might accrue to them, or to the structure through them, from their exposed and partly unconnected situation. The graduated pyramidal stylobate on which the structure rests also bears a certain proportion to the standard which is the measure of all the rest; and so every part is determined by the capacity of the sustaining power. Though the Doric order thus possesses, as it were, a self-proportioning power, which will secure harmony in its composition under any circumstances, yet skill and taste in the architect are necessary to determine, according to them, the number of diameters the column shall have in height, and according to that assign the height of the entablature. For these two points in proportioning, and for appropriate detail and enrichment, he may, without servility, refer to the ancient examples; with the confidence, moreover, that in availing himself of their beauties he acquires the power of producing an object that shall be itself beautiful, while he can avoid being a mere copyist in the adaptation and arrangement of the materials of his composition, as well as in the selection

of them. We cannot discover that the elevation of the pediment depended so immediately on the common standard, though in the best examples the tympanum will be found to be about one diameter and a half in height.

The Ionic and Corinthian, or Voluted and Foliate orders, do not possess that innate principle of harmony which pervades the Doric, and therefore they are, as styles, less perfect, and depend more on factitious combinations. The Greek compositions of Ionic and Corinthian are of such consummate beauty in every particular, that their examples appear perfect, and may therefore be taken as models for study, in preference to the rules which have been laid down for those orders, without a knowledge of these exemplifications. With a consciousness of their inferior capacity to produce grand and harmonious effects in such arrangements as their temples require, the Greeks never applied either the Ionic or the Corinthian peripterally, and, as far as we have certain knowledge, only the latter in prostyles. Whether the Ionians did or did not, cannot be satisfactorily ascertained, as their temples are in every case so much destroyed, that it is impossible, at least without more care and attention than they have yet received, to make out satisfactorily what their plans were. In the Ionic and Corinthian orders, the proportions of the various parts are generally made dependent on the diameter of the column, as in the Doric; but the intercolumniations, and consequently the general proportions, of a composition, are not determined by the column and its accessories according to their capacity, but must be left to the taste and skill of the architect, as well as the columnar proportions themselves. This gave rise to the rules referred to, which are laid down by Vitruvius, for what he calls the "Five Sorts of Edifices," or, more correctly, species of intercolumniation. They are pycnostyle, systyle, diastyle, araeostyle, and eustyle, to each of which a fixed space is assigned. Architects will, however, act more wisely in judging for themselves, by reference to the best models of antiquity, what proportion constitutes an *Eustyle* intercolumniation, according to the application of his ordinance, than by attending to such irrational dogmas as are contained in that classification.

The temples of the Greeks are described, according to their external arrangement, as being either in antis, prostyle, amphiprostyle, peripteral, pseudo-peripteral, dipteral, or pseudo-dipteral; and internally, as cleithral or hypæthral. The columnar arrangement in antis is not common in Greek architecture, though there are examples of it, generally of the Doric order. The inner porticoes or pronaoi of peripteral temples are for the most part placed in antis, as may be seen by reference to the examples, in which columns stand between the antæ. The Ionic temples of Athens are the principal examples of the simple prostyle. They may be called apteral, if it be necessary to distinguish them from peripteral, as the latter are prostylar; but the former term alone is sufficient. Neither does Greek architecture present more than one example, and that is at Athens also, of an amphiprostyle, except in the same peripteral structures, which are also amphiprostylar. Almost all the Doric temples are peripteral, and being peripteral, they are, as a matter of course, amphiprostylar, as we have just remarked; so that the former term alone is used in describing an edifice of that kind, with the numeral which expresses the number of columns in each of its prostyles. There is but one known example of Greek antiquity of a pseudo-peripteral temple, and that is the gigantic fane of Jupiter Olympius at Agrigentum in Sicily. It is not even prostylar, for the columns on its fronts are attached, as well as those on its flanks. The dipteral arrangement is found at Selinus, in an octastyle temple; and in some cases the porticoes of peripteral temples have a pseudo-dipteral projection, though no perfect example of the pseudo-dipteros exists.

Most of the temples of the Greeks were cleithral; those to the inferior and demi-gods were invariably so. The fanes of the supreme divinity were almost as invariably hypæthral, and frequently those of other superior gods were of the latter description also. The Doric order was never used by the Greeks in mere prostyles; consequently there is no Doric temple of the tetrastyle arrangement, for it is incompatible with the peripteral, the tetrastyle examples which do exist being all Ionic.[1] With very few exceptions, all the Doric temples of the Greeks are hexastyle. Their queen, however, the unmatched Parthenon, is octastyle; and the pseudo-peripteral fane of Jupiter Olympius at Agrigentum, just referred to, presents the singular arrangement, heptastyle. No example exists in Greek architecture of a portico of more than eight columns, except the mis-shapen monument called the Basilica at Pæstum, the Thersites of its style, be so considered, and that has a front of nine columns, or an enneastyle arrangement.

It may be here remarked, in support of the opinion we have given as to the authority of Vitruvius, that, according to him, peripteral temples have on each flank twice the number of intercolumniations they have in front; thus giving to a hexastyle eleven, to an octastyle fifteen columns, and so on, whereas in the Greek temples this is never the case, for they always have more. The best examples have two, some have but one, but many have three, and in one instance there are four intercolumniations more in flank than in front. Again, he limits the internal hypæthral arrangement to those structures which are externally decastyle and dipteral, though an example, he says, existed in Greece of an octastyle hypæthros, and that was a Roman structure. Now, the Parthenon is an octastyle hypæthros, but all the other hypæthral temples, both in Greece and her colonies, are hexastyles, except perhaps the octastyle dipteral at Selinus; and there is no evidence in existence that the Greeks ever constructed a decastyle dipteral temple.

A Greek temple, whose columnar arrangement is simply in antis, whether distyle or tetrastyle, consists of pronaos and naos or cella. A tetraprostyle may have behind it a pronaos and naos. An amphiprostyle has, in addition to the preceding, a postieum, but is not understood to have a second entrance. The porticoes of a peripteral temple are distinguished as the portieus and postieum, and the lateral ambulatories are incorrectly called peristyles. It may indeed be here suggested, that as the admixture of Latin with Greek terms in the description of a Grecian edifice cannot be approved of, it would perhaps be better to apply the term *stoa* to the colonnaded platform or ambitus altogether, and distinguish the various parts of it by the addition of English adjectives: or the common term portico would be quite as well with front, back, and side or lateral, prefixed, as the case may be. Within the back and front stoas or porticoes, then, a peripteral temple has similar arrangements in antis, which are relatively termed the pronaos and opisthodomus, with an entrance only from the former; unless there should exist, as there does in the Parthenon, a room or chamber within the opisthodomus, supposed to be the treasury, when a door opens into it from the latter. Besides these,

Pl. LIV.

Pl. LVI. Fig. 2 and Pl. LVI. Fig. 2

Pl. LVIII. Fig. 3.

Pl. LVII. Fig. 3.

[1] Athens itself containing a Doric tetraprostyle, may seem to contradict this; but it must be recollected that we have already said (page 331), that in speaking of Greek architecture, we exclude all the examples, even in Greece itself, which were executed under the Roman dominion, for they bear the Roman impress; and that is one of them.

Grecian Structures.

a Greek temple of the most ramified description consists only of a cell, in those which are cleithral; and of a naos, which is divided into nave and aisles, to use modern ecclesiastical terms, in an hypæthral temple.

The only pure Greek architectural works that remain to us, and of which we have certain information, besides temples, are, it has been already stated, propylæa, choragic monuments, and theatres. The Propylæum, by way of eminence, that to the Acropolis of Athens, is the entrance or gateway through the wall of the peribolus into it. It consists of a Doric hexaprostyle portico internally, with a very singular arrangement of its columns, the central intercolumniation being ditriglyph. This was done probably to allow a certain procession to pass, which would have been incommoded by a narrower space. Within the portico there is a deep recess, similar to the pronaos in a temple, but without columns in antis; a wall pierced with five doorways corresponding to the intercolumniations of the portico, close the entrance; and beyond it is a vestibule, divided into three parts by two rows of three Ionic columns, and forming an outer portico, fronted externally by a hexaprostyle exactly similar to that on the outside. Right and left of it, and setting out about one intercolumniation of the portico from its end columns, at right angles, are two small triastyle porticoes in antis, with chambers behind them. These have been called temples, but most probably they were nothing more than porters' lodges or guard-houses. The whole structure, though extremely elegant, and possessing many beauties, is not a good architectural composition: the unequal intercolumniation detracts from its simplicity and harmony. The use of Ionic columns in a Doric ordinance is equally objectionable; and their elevation from the floor of the portico on insulated pedestals is even worse, though their intention is obvious; and without raising them, the ceiling might have been too low, or they must have been made taller.[1] The uneven style of the small temples or lodges is not pleasing, even though they be taken as flank and not as front compositions; and, moreover, their entablature abuts indefinitely against the walls of the larger structure, both internally and externally, to the total destruction of the harmony of the general composition. Indeed the unequal heights of the entablature of the greater ordinance involves a fault, if there were not something to prevent them from being seen in the same view, which it requires more than all the beauties of detail and harmony of proportion to countervail.

Pl. LX. Fig. 1 & 2.

The choragic monument of Lysicrates, vulgarly called the Lanthorn of Demosthenes, at Athens, is a small structure, consisting of an elegant rusticated quadrangular basement or podium, which is more than two fifths of the whole height, surmounted by a cyclostyle of six Corinthian columns, attached to, and projecting rather more than one half from, a wall which perfects the cylinder up to the top of their shafts, where it forms a podium for tripods the height of the capitals. A characteristic entablature rests on the columns, and receives a tholus or dome, which is richly ornamented, and terminates in a foliated and heliced acroterium. To this Stuart has added dolphins as supporters, and has placed on the summit a tripod, which was the prize in the choragic festival; thus completing perhaps the most beautiful composition in its style ever executed. In Vitruvian language the arrangement of this edifice would be called monopteral; but it is more correctly cyclostylar, or, perhaps, because of the wall or core, it may be termed a pseudo or attached cyclostyle. The basement of this monument is eminently bold and simple, admirably proportioned to the rest of the structure, and harmonizing perfectly with it. The columnar ordinance is the only perfect specimen of the style in existence of pure Greek origin, and it has never been surpassed, perhaps not equalled, in beauty elsewhere. The most exquisite harmony reigns throughout its composition: it is simple without being poor, and rich without being meretricious; and the same applies to the superimposed tripod and its supports.

Totally different in style and arrangement, and far inferior in merit, is the choragic monument of Thrasyllus. It bears, however, the impress of the Grecian mind. This composition is merely a front to a cave, consisting of three pilasters proportioned and moulded like Doric antæ, and supporting an entablature similar in style, but too shallow to harmonize with them. Above the entablature there is an attic or parapet, divided into three compartments horizontally. The two external form tablets with a cornice or impost on them, and the central is composed of three receding courses, on the summit of which is seated a draped human figure, whether male or female, in its mutilated state is not determinable. The entablature, instead of triglyphs in the frieze, has laurel wreaths; and it would appear as if the absence of that feature had deranged the whole composition. The two outer pilasters are of good proportion, and the architrave is well proportioned to them; but the frieze and cornice are both too narrow, and the spaces between the pilasters, equivalent to intercolumniations, are too wide. The third pilaster, itself inharmonious, is absurdly narrow, being narrower than the others; and, standing immediately under the statue, evidently to support it, its meagreness is the more obvious and striking. In spite of all this, the general outline of the structure is simple and pleasing, the detail is elegant, and the execution spirited and effective. This little monument is, however, a proof that the Greeks were not so excellent in architectural compositions at all times, as in the self-composing Doric temples, and in the choragic monument of Lysicrates; and to this evidence may be added that of the triple temple in the Acropolis of Athens. It consists of an Ionic hexaprostyle in front, resting on a bold, continuous, and well-proportioned stylobate, and forming the entrance to a parallelogramic cella, but, from all that has yet been discovered, without a pronaos in antis. The back-front consists of four columns like those of the portico, attached in antis; and the flanks are broad and bold, crowned by the well-proportioned and chaste entablature, with the enriched congeries of mouldings and running ornament of the antæ under it. In the absence of a pronaos to give depth to the portico, the composition was defective, but otherwise simple and harmonious. It was, however, completely spoiled by the attachment of a tetraprostyle to one of its sides, Ionic certainly, like that in front, but not only in a different manner, but of a different size; beautiful in itself, but a blot on the main building, with which it harmonizes in no one particular, being altogether lower; for the apex of its pediment only reaches to the cornice of the former. This and the Caryatidean portico are omitted in the example. In a similar situation, against the other side is attached a similar arrangement of Caryatides, a tetraprostyle of female figures raised on a lofty basement, and yet not reaching to the entablature of the main building,—according in no one particular either with it or with the portico on the other side, and altogether forming the most heterogeneous

[1] An editorial note in the new edition of *The Antiquities of Athens* says that "they are incorrectly mounted on pedestals" in Stuart and Revett's *Restoration*. This structure cannot perhaps fairly be judged of, until its site and remains shall have been examined without the jealous supervision of a Turkish governor.

and inharmonious combination imaginable. Yet the two Ionic porticoes are the most beautiful examples of their order in existence, and perhaps, it may be added, that were ever executed,—arranged in the finest proportion, and with the most exquisite details and enrichments. The Caryatidean frontispiece, also, for more it cannot be called, is full of architectural beauties, though it is most injudiciously collocated.

The theatres of the Greeks, it has been already intimated, present but little to interest in the view we are taking of architecture. They were not structures, but excavations; and whatever decoration they may have received to make them objects of interest externally, is, in every known example, entirely gone; and attempts to restore them from their existing remains, and the information to be derived from ancient writers, would be futile, without a knowledge of Greek architecture gained elsewhere, proving that they themselves cannot furnish it, and of course cannot yield it to us. No example of it furnishing us with matter for architectural illustration, we should gain no information in furtherance of our present subject by treating of it here.

The division of the columnar architecture of the Greeks and Romans into orders by the Italian architects of the fifteenth century, according to the laws of Vitruvius, and the universal reception of that mode of arranging it, almost imposes on us the necessity of adopting the same course, and laying down a standard or model for each. But instead of so doing, we think it better to give each school separately, and describe the general features of the orders as they occur in the works of each,—pointing out, moreover, the varieties that exist, and prevent the monotony consequent on restricted forms and proportions. We retain, too, the term "Order," and the names in general use, without consenting to the propriety of either the one or the other; for if it be judicious to divide Greek and Roman columnar architecture into orders, there can be no reason why Egyptian, Hindoo, Persian, or any other style, should not be classed in a similar manner. Moreover, there is nothing in any one "order" that, were it not for custom, would not be thought as fitting in any other as in that to which it may belong. The Greeks did not hesitate to put triglyphs in the frieze of an entablature whose columns were fillet-fluted and had foliated capitals, as some ruins at Pæstum attest. As to names, the Doric might, as we have said, be called Corinthian with more propriety; the Ionic, Samian; and the Corinthian, Athenian; referring to the oldest known examples of each. The term Style would be more correct than Order, as it would indicate the column as the feature referred to, without conveying the idea of fixed rules; and architectural works into which columns do not enter need not be constrained to admit the arrangement of some Order in the composition, proportion, and detail of its various parts. In naming, too, the Doric might be called the Greek sacred or triglyphed style; the Ionic, the Voluted style; and the Corinthian, the Foliated; thus admitting any varieties of combination which could be expressed as composites of the voluted and foliate, or of the foliate and triglyphed, as the case might be.

An Order, according to Mr Gwilt, is "an assemblage of parts, consisting of a base, shaft, capital, architrave, frieze, and cornice, whose several services requiring some distinction in strength, have been contrived or designed in five several species,...each of which has its ornaments as well as general fabric proportioned to its strength and character." Perrault says that an order may be defined "a rule for the proportion of columns, and for the form of certain parts which belong to them, according to the different proportions which they have." We would have it understood to be a species of columnar arrangement, differing in its forms and general proportions, and in some leading features, from any other. Greek columnar architecture may thus be divided into the three arrangements or orders, Doric, Ionic, and Corinthian, which form its classes or styles. In considering them, however, it is necessary to discharge the mind of all the absurdities of the Italo-Vitruvian school about the proportions of the human figure being applied to columns, whether virile, matronal, or virginal; about the trunks of trees and rafters' feet; whether Doric columns should not have bases because men have feet, or that Ionic columns should have them because women wore sandals; that the guttæ in a Doric entablature should be conical, and not pyramidal, because they are to look like drops of water; that sculls, furies, thunderbolts, and daggers may be used to enrich a Doric frieze, but that spears, and swords, and stars, and garters may not;—these, with the thousand other puerilities of the *Cinquecentists*, whether Italian, French, or English,—whether acquired from the writings of Palladio and Scamozzi, of Perrault and Leclerc, or of Wotton and Chambers,—must be forgotten, and the greater or less degree of beauty resulting from this or that mode of arrangement and detail alone attended to.

Not to induce the idea that the quoted examples of the antique should be imitated to the line and letter, but rather in spirit, we shall speak of the proportions of their various parts generally; though it must at the same time be understood that much of the beauty of a columnar composition depends on its minutiæ: still it is not necessary that these minutiæ should be mere repetitions of an original; it is in the spirit of the antique models that excellence is to be sought, and not in crude rules for their reproduction.

Of the Grecian Doric.

This order may be divided into three parts, Stylobate, Column, and Entablature. The stylobate is from two thirds to a whole diameter of the column in height, in three equal courses, which recede gradually the one above from the one below it, and on the floor or upper step the column rests. That graduation, it may be remarked, does not appear to have been made by the ancients to facilitate the access to the floor of the stoa or portico, but on the principle of the spreading footings of a wall, to give both real and apparent firmness to the structure, both of which it does in an eminent degree.

The column varies in different examples from four to six diameters in height, of which the capital, including the necking, is rather less than half a diameter: in those cases in which a necking does not exist, the capital itself occupies nearly the same proportion. The shaft diminishes in a slightly curved line, called entasis, from its base or inferior diameter upwards to the hypotrachelium, leaving it at that place, or at the superior diameter, from two thirds to four fifths of the lower or inferior, which latter is the diameter always intended when the term is used as a measure of proportion. The capital consists of a necking, an echinus or ovalo, and an abacus; the necking is about one fifth of the height of the capital, and the other two members equally divide the remaining four fifths: when there is no necking, the ovalo occupies the greater proportion of the whole height. The abacus is a square tablet, whose sides are rather more than the inferior diameter of the column. The corbelling of the ovalo adapts it to both the diminished head of the shaft and the extended abacus, flowing into the one, and forming a bed for the other by means of a graceful cyma-reversa; but its lower part is encircled by three or four rings or annulets, which are variously formed in different examples,

Pl. LV. Fig. 10. Pl. LVII. Fig. 4 & 9. Pl. LVIII Fig. 4. Fig. 6 & 7.

Grecian Doric.

and which are the means of giving the echinus form to the great moulding, although it is, as we have said, part of a cyma-reversa. The shaft is divided generally into twenty flutes; but there are several examples with sixteen, and there is one with twenty-four. The flutes are sometimes segments of circles, sometimes semiellipses, and sometimes eccentric curves. They always meet in an arris or edge, and follow the entasis and diminution of the column up through the hypotrachelium to the annulets, under which they finish, sometimes with a straight and sometimes with a curved head. At the base they detail on the pavement or floor of the stylobate.

Pl. LVII. Fig. 12. Pl. LVIII. Fig. 8 & 14.

Fig. 4.

The third part of the order, the entablature, ranges in various examples from one diameter and three quarters to rather more than two diameters in height, of which about four fifths is nearly equally divided between the architrave and frieze, and the cornice occupies the remaining one fifth: this is in some cases exactly the distribution of the entablature. The architrave is in one broad face, four fifths, and sometimes five sixths of its whole height; and the remaining fifth or sixth is given to a projecting continuous fillet called the tænia, which occupies one half the space, and a regula or small lintel attached to it, in lengths equal to the breadth of the triglyphs above in the frieze. From the regulæ six small cylindrical drops called guttæ depend. There are examples to the contrary, but it may be taken as a general rule, that the architrave is not in the same vertical line with the upper face of the shaft, or its circumferential line, at the superior diameter, but is projected nearly as much as to impend the line or face of the column at the base. The frieze, vertically, is plain about six sevenths of its whole height, and is bounded above by a fascia, slightly projecting from it, which occupies the remaining seventh. Horizontally, however, it is divided into triglyphs and metopes, which regulate the intercolumniations in the manner that has been already described; the former being nearly a semidiameter in width, and the latter the space interposed between two triglyphs, generally an exact square, its breadth being equal to the whole height of the frieze, including the fascia. This latter breaks round the triglyphs horizontally, and is a little increased in depth on them. Each glyph, of which there are two whole ones and two halves to every tablet, is one fifth of the width of the whole, and the interglyphs are each one seventh of the whole tablet or triglyph. The glyphs detail on the tænia of the architrave, but are variously finished above. In some examples they are nearly square-headed, with the angles rounded off; in others the heads are regular curves, from a flat segment to a semiellipsis. The semiglyphs are finished above in a manner peculiar to themselves, with a turn or drop; but hardly two examples correspond in that particular. The tablets in which the glyphs are cut are vertical to the face of the architrave, the metopes recede from them like sunk panels; these are often charged with sculptures, and indeed almost appear contrived to receive them. The third and crowning part of the entablature, the cornice, in what may be considered the best examples, projects from the face of the triglyphs and architrave about its own height. Vertically, it is divided into four equal parts, one of which is given to a square projecting fillet at the top, with a small congeries of mouldings, different, and differently proportioned to each other, in various examples. Two other parts are given to the corona, and the remaining fourth to a narrow sunk face below it, with the mutules and their guttæ. These latter form the soffit or planceer of the cornice, which is not horizontal or at right angles to the vertical face of the entablature generally, but is cut up inwards at an angle of about 80°. The width of the mutules themselves is regulated by that of the triglyphs over which they are placed, to which it is exactly equal. They are ornamented each with three rows of six small cylinders, similar to those which depend from the regulæ under the triglyphs and on the architrave. There are twice the number of mutules that there are of triglyphs, one of the former being placed over every metope also in the manner the examples indicate.

Grecian Doric.

This completes the Greek Doric Order according to the generally received sense of the term; but there are other parts necessary to it. In the front or on the ends of a temple, or over a portico, a pediment is placed. Its intention is obviously to inclose the ends of the roof, but it forms no less a part of the architectural composition. In reason, it should be raised as much as the roof required; but when the span is great that would be unsightly; and reference appears to have been made to the common standard of proportion, as the pediments of most Doric temples are found to be about one diameter and a half in height at the apex of the tympanum, which in a hexastyle arrangement makes an angle at the base of about 14°, and in an octastyle about 12½°. The pediment is covered by the cornice, without its mutules, rising from the point of its crowning fillet, so that no part of it is repeated in profile. Another moulding, however, is superimposed: sometimes this is an ovalo with a fillet over it, and sometimes a cymatium. It varies much in its proportion to the cornice, but in the best examples it is about one half the depth of the latter without its mutules. Ornaments of various kinds, statues or foliage, are believed to have been placed on the apices and at the feet of pediments as acroteria. Of these, however, we have no actual remains; but indications of the plinths or blocks which may have received them exist, and such things appear represented in ancient coins and medallions. The tympana of pediments are well known as receptacles of ornamental sculpture. On the flank of a Doric temple, the cornice supported a row of ornamented tiles called antefixæ. These formed a rich and appropriate ornament, but they rather belonged to the roof than to the columnar arrangement or order. The antefixæ covered the ends of the joint-tiles as the pediments did those of the roofs; and corresponding ornaments called stelai rose out of the apices of the joint-tiles, forming a highly enriched ridge.

Pl. LVII. Fig. 1.

Pl. LVI. Fig. 1.

A secondary Doric order arises in the disposition of a Grecian temple, from the columns of the pronaos and the inner part of the external entablature continued and repeated. Of this the frieze is generally without triglyphs, though there may be regulæ and guttæ on the architrave. The fascia of the frieze is either moulded or enriched on the face; and, instead of a cornice, the beams of the ceiling are laid at equal intervals to support sunk panels or coffers, in which there may be flowers or other enrichments.

Fig. 9.

The proper composition and arrangement of antæ are as necessary to the perfection of the Doric order as that of the columnar ordinance itself, especially if the latter be in antis. A slight projection is made from the end and side face of a wall, forming a species of pilaster, whose front shall be nearly equal to the diameter of the columns to which it is attached, exactly equal indeed to the soffit of the entablature, whose faces have been described to impend the circumferential line of the column a little above its base. This rests on the stylobate in the same manner as the columns do, with sometimes a small continuous moulding as a base; and its capital is a congeries of mouldings, about the depth of the abacus, with a plain fascia corresponding to the ovalo of the columnar capital. The entablature of the order to which it is attached rests on it, and, continuing along the flank of the building, is received by a similar combination at the other end. These, it may be remarked, were never diminished or fluted.

Fig. 2, & 10; Pl. LV Fig. 2, & 9.

Grecian Ionic.

Being projections from the ends of walls, they could not be diminished without involving an absurdity; and fluting on a straight surface must be productive of monotony, as the flutes can only project a series of equal and parallel shadows. Not so, however, with columns, on whose rotund surface fluting produces a beautiful variety of light and shade in all their gradations, which it could not possess without that enrichment; for on a plain column neither are the lights so bright nor the shadows so dark as in the former case, nor are they so finely diffused over the whole surface in the one as in the other.

In the only example which occurs in the ancient architectural remains of attached Doric columns, that of the pseudo-peripteral temple of Jupiter Olympius at Agrigentum, the stylobate is peculiarly arranged. The upper gradus is grooved, and detailed round the columns and along the walls between them; and a congeries of vertically arranged mouldings and fillets rests on it, and receives the base of the column.

Such are the materials of which the Greeks composed their beautiful temples, the manner of whose composition has been already described. Of their effect, however, it is impossible to form a competent idea without seeing one. And whence, it may be asked, does their interest arise? Pl. LI. From their simplicity and harmony;—simplicity, in the long unbroken lines which bound their forms, and the breadth and boldness of every part; such as the lines of the entablature and stylobate, the breadth of the corona, of the architrave, of the abaci, of the capitals, and of their ovalos also; in the defined form of the columns, and the breadth of the members of the stylobate;—harmony, in the evident fitness of every part to all the rest. The entablature, though massive, is fully upborne by the columns, whose spreading abaci receive it, and transmit the weight downwards by the shafts, which rest on a horizontal and spreading basement; the magnitude of every part, as we have before had occasion to remark, being determined by the capacity of the sustaining power. Besides graceful and elegant outline, and simple and harmonious forms, these structures possess a bewitching variety of light and shade, arising from the judicious contour and arrangement of mouldings, every one of which is rendered effective,—by the fluting of the columns and the peculiar form of the columnar capital, whose broad, square abacus projects a deep shadow on the bold ovalo, which mingles it with reflections, and produces on itself almost every variety. The play of light and shade, again, about the insulated columns, is strongly relieved and corrected by the deep shadows on the walls behind them; and in the fronts, where the inner columns appear, the effect is enchanting. For all the highest effects which architecture is capable of producing, a Greek peripteral temple of the Doric order is perhaps unrivalled.

Of the Grecian Ionic.

Not less Hellenic in its detail than the national Doric is the graceful and elegant style called the Ionian, whose proportions and peculiarities we take from the perfect examples of the Athenian Acropolis.

Pl. L. This order may also be considered in three similar parts, Stylobate, Column, and Entablature. The stylobate is in three receding equal courses or steps, whose total height is from four fifths of to a whole diameter. The column, consisting of base, shaft, and capital, is rather more than nine diameters in height, of which the base is two fifths of a diameter; and the capital, including the hypotrachelium, is in one case three fourths, and in the other seven eighths of a diameter high. The base consists of a congeries of mouldings, extending gradually from one diameter and a third to a diameter and a half, and its height is in three nearly equal parts, with two equal fillets separating them. The lowest, a torus, rests on the top of the stylobate or floor of the portico, a fillet divides that from a scotia, a second fillet intervenes that and a second torus, and a third fillet bases the apophyge or escape of the shaft. The upper torus of the base is, in one example, fillet-fluted horizontally; and, in the other, the same member is enriched with the guilochos. The shaft diminishes with entasis from its lower or whole diameter, to above five sixths of it immediately under the hypotrachelium. It is fluted with twenty-four flutes and alternating fillets, which follow the diminution and entasis of the column. The flutes in plan are nearly semiellipses, and they finish at both ends with the same curve: a fillet is in thickness nearly one fourth the width of a flute. The difference in the height of the capital is in the length of the necking, which in one case is separated from the head of the shaft by a carved bead, and in the other by a plain fillet. Above the necking, a height of about one third of a diameter is occupied by a congeries of three spreading or corbelling mouldings, a bead, an ovalo, and a torus, which are all appropriately carved. On these rest the parallelogramic block, on whose faces are the volutes, and whose ends are concaved into what is technically termed a bolster, to connect them. This part is about one third of a diameter in height, and includes a rectilinear abacus, whose edges are moulded to an ovalo, and carved with the egg and tongue ornament. The volutes are three fifths of a diameter in depth, and extend in front to one diameter and a half; and they are nearly a semidiameter apart. The flowing lines which connect the volutes can only be understood by reference to the example. The Fig. 5. bolsters are fluted vertically, with alternate fillets, on Fig. 12. which are carved beads. An ornament composed of the honeysuckle with tendrils encircles the necking of the column. It must be remarked, that as the capitals are parallelogramic, and present but two similar fronts, to preserve the appearance of volutes externally on all sides, the capitals of those columns which occupy the external angles of porticoes are differently arranged. The outer Fig. 16. volute is bent out at an angle of 45°, and volutes are put on the end or side-front of the capital also, the outer one being the other side of the angular volute of the front. To suit the angle internally, the two volutes of the inner face are placed at right angles to each other: this is, however, at best but an awkward expedient, and need not be employed when a portico projects only one intercolumniation.

The entablature, which is rather more than two diame- Fig. 5. ters in height, is also divided into three parts—architrave, frieze, and cornice—which may be proportioned by dividing the whole height into five parts, four of which, as in the Doric, may be again equally divided between the architrave and frieze. The cornice, however, in the examples referred to, does not occupy one fifth of the entablature; but if it had a fillet over the upper moulding, which it appears to want, that would be just its proportion. If the architrave be divided into nine parts, seven of them may be given to three equal fascias, which slightly project the one before the other; the first or lowest, which is vertical to the circumferential line of the inferior diameter, being covered by the second, and the second by the third. The remaining two ninths form a band of mouldings corbelling a broad fillet, which separates the architrave from the frieze: these mouldings are enriched. The frieze, which does not project quite so much as the lowest fascia of the architrave, is, in the Athenian examples, quite plain; but it may be enriched with foliage, or made the receptacle of sculpture in low relief. The cornice projects from the face of the frieze rather more than

Grecian Ionic.

as much as its whole height, and is composed of bed mouldings, a corona, and crown mouldings. The first are a carved bead and carved cyma-reversa, the former of which only occupies a portion of the height of the cornice, as the planceer is cut up inwards in the manner represented by dotted lines in the example, to a sufficient depth for it; the crown mouldings, which consist of a carved ovalo above a carved bead, are rather more than one fourth of the whole cornice; and the corona occupies the rest of its height, except that small portion given to the bead of the bed mould. A fillet above the crown mouldings, as already intimated, is certainly necessary to complete the order and receive the antefixæ, as described in the Doric, for the flank of a temple.

Fig. 1 & 2. The pediments in the Ionic examples are rather flatter than in the Doric, the angle made by the covering cornice with the base being, in a hexastyle, less than 14°. A vertical fillet, with a small moulding, equal in depth to the two crown mouldings of the cornice, covers them in the pediment, in the place of the cyma-recta or ovalo used in the Doric order. The intercolumniation used in these examples is, in the one two diameters, and in the other three diameters and one sixth.

A much greater variety is found in the composition of the Ionic than of the Doric order. Indeed the examples of the Athenian Acropolis alone have neckings; in all the others the shaft runs up to the corbelled mouldings, which bed the block of the volutes, and the flutes finish under them. Neither have they a torus in that congeries, but a bead and ovalo alone, which latter makes an inconvenient projection under the pendent lines that connect the volutes, and thus the capital is not more than half a diameter in height.

The Ionian or Asiatic examples of this order are far inferior to those we have referred to. Their bases are differently, and certainly less elegantly composed. They are without hypotrachelia, as may have been inferred; they want the torus in the capital; and, in most cases, instead of flowing, pendent lines, they have straight lines connecting the volutes. Their entablatures are not so finely proportioned, nor so delicately executed. The coronas want breadth, and the bed moulds of the cornice are as much too heavy as those of Athens are perhaps too light. Indeed, upon the whole, they have more of the grossness of Roman architecture than of the delicacy and elegance of Grecian, though the Ionian examples are supposed to be the models of those of Athens.

Fig. 10. The width of the antæ of the Ionic order is determined, as in the Doric, by the soffit of the entablature; and it will, of course, be exactly the same as, or rather less than, the inferior diameter of the column. It is slightly raised, too, from the face of the wall at the ends of which it stands. The base of the antæ is, in one of the two examples of the Acropolis, a little deeper than that of the column, having a small projecting moulding between the lower torus and the floor; and the lower torus itself is reeded. In the other example there is no difference in the form and proportion of the antæ and columnar bases, but both the tori are fluted horizontally, with beaded fillets between the flutes. The antæ cap consists of a congeries of corbelling mouldings, nearly one third of a diameter in height. It is divided into three nearly equal parts, the lowest of which is composed of a bead and an ovalo; the second of another bead and a cyma-reversa, all carved; and the third of a plain flat cavetto, with a narrow fillet and small crowning cyma-reversa, forming an abacus. The necking is like that of the capital, and is enriched in the same manner. Fig. 3. The cap or cornice thus formed breaks round the projection of the antæ, and is continued along the wall under the entablature the whole length of the building, or till it is impeded by some other construction, and the base is continued in like manner.

Grecian Corinthian.

Attached columns have the voluted capital, but their base is that of the antæ; and it is detailed round them and along the wall to which they belong, as with the antæ. It must be remembered, however, that the attached columns in the triple temple are about one ninth less in diameter than those which are insulated, though they are similar in other respects, and have the same entablature. Fig. 2.

The back of the triple temple, between the attached columns, presents the only example in Greek architecture of windows. These are rather more than twice their width in height, and are narrower at the top than at the bottom. They rest on a broad, bold sill, which is equal in depth to two sixths of the opening, and are surrounded externally by a congeries of mouldings, which, with a plain fascia, constitute an architrave. This architrave is one fourth the opening in width; it diminishes with the window, and in the same proportion, and is returned above in two knees, which are made vertical to its extreme point at the base.

Of the Grecian Corinthian.

The importance which the Greeks attached to a graduated stylobate, and the necessity of giving it a relevant proportion in a columnar ordinance, are evinced in the only example of this order which remains to us of Grecian origin. Unlike the Doric and Ionic in its application, which is in temples of rectangular form, whose whole height they occupy, this is attached to a small circular structure, resting on a lofty square basement; and yet, like those orders, it has a stylobate in receding courses, and in plan, too, corresponding with the arrangement of the columns, and not with that of the substructure; thus offering further proof that the stylobate was considered a part of the columnar ordinance. Thus the Corinthian order also consists of stylobate, column, and entablature. The stylobate is rather more than a diameter in height, and is divided into three parts, but not equally, in consequence, it is probable, of the peculiar position of the ordinance. The two lower grades have vertical faces, are of equal depth, and they occupy three fourths of the whole height; the third step occupies the remaining one fourth, and is moulded on the edge, in exquisite harmony with the more ornate style, of which it forms a part. Like the column of the Ionic order, that of the Corinthian consists of base, shaft, and capital: it is ten diameters in height. The base is rather more than one third of a diameter high, and is composed of a torus and fillet, which are nearly two fifths of its whole height; a scotia and another similar fillet, rather less than the former; and a second torus or reversed ovalo, one fifth the height of the base, on which rests a third fillet basing the apophyge of the shaft. The extent or diameter of the base, at the lower torus, is rather more than one diameter and a half. The shaft diminishes with entasis to five sixths of its diameter at the hypotrachelium, and, like that of the Ionic order, has twenty-four flutes and fillets. The flutes are semiellipses, so deep as nearly to approach semicircles: they finish in the apophyge at the foot of the shaft, in the same manner and form; and at the head they terminate in leaves, to which the fillets are stalks. The fillets are rather more than one fourth the width of the flutes. The hypotrachelium is a simple channel or groove immediately under the capital. The capital itself is a diameter and rather more than one third in height: its core is a perfect cylinder, in bulk rather less than the superior diameter of the shaft. This is banded by a row of water leaves, whose profile is a flat cavetto, one sixth of the whole height, and another of leaves of the acanthus, with flowered buttons attaching them to the cylin-

Pl. LX Fig. 1. Fig. 2. Fig. 1

Greek Corinthian. der. These latter have the contour of a cyma-recta, and are twice the height of the last, or one third of the whole capital. Rather more than another third is occupied by helices and tendrils, which latter support a honeysuckle against the middle of the abacus; and the abacus itself, resting on and covering the whole mass, is but little more than one seventh of the whole height. This member in plan can only be described as a square whose angles are cut off at 45°, and whose sides are deeply concaved. In profile it consists of a narrow fillet, an elliptical cavetto or reversed scotia, and another fillet surmounted by a small ovalo, or rather a moulding whose profile is the quadrant of an ellipsis.

The entablature of this order is two diameters and two sevenths in height. It also consists of architrave, frieze, and cornice, of which the first occupies one tenth more than a third, the second rather more than as much less than that proportion, and the cornice is so much more again above one third. The architrave is divided, like that of the Ionic order, into three equal fascias, which occupy all but one sixth of its whole height, and that is given to a corbelled band, consisting of a bead, cyma-reversa, and fillet, separating the two members of the entablature. The fascias of the architrave, it must be remarked, are not perpendicular, but incline inwards, so that their lower angles are all in the same vertical line, which impends the surface of the shaft about one third of its height from the base. The frieze is one plain band, slightly inclining inwards, like the fascias of the architrave, and slightly projected beyond them: in this example it is enriched with sculptures. The cornice consists of a deep congeries of bed mouldings, and a corona, with the accustomed small crown mouldings and fillet. Its extreme projection is nearly equal to its whole height: of this the bed-mouldings project about two fifths. As in the Ionic cornice, additional height is given to the bed-moulds, by undercutting the planceer. In this case, indeed, it is done to nearly one fourth the height of the corona. One sixth the height of the cornice is given to a flat bead and an ovalo, which are immediately above the frieze, and which base a broad dentilled member that occupies more than one fourth of the whole cornice. This is surmounted by a listel or broad fillet, above which is a cyma-recta, whose narrow fillet nearly reaches the horizontal plane of the planceer, and separates it from a cyma-reversa that beds the superimposed projecting corona. This latter is only three eighths of the whole cornice, and nearly one of the three is given to the ovalo and fillet, the bed-moulds alone occupying five eighths. The cornice is surmounted by a cut fascia supporting honeysuckle antefixæ, which may indeed be taken as a part of the order, as the solitary example in question presents it. This, however, we know, from the Doric and Ionic structures, to be a modification of the flank ornament of temples; and we may suppose from analogy, that if used in a portico, the cornice of this order would have a cyma-recta to crown it on the inclined side of the pediment. The intercolumniation of this example is two diameters and one third.

Of Corinthian antæ we have no examples, nor indeed have we of insulated columns; but as we find in the Ionic examples quoted, that the attached columns are less in proportion to the entablature than those which are insulated, we may conclude that it would be the same with this; thus reducing the entablature to two diameters, the ordinary average of that part in Greek columnar architecture.

Of the Caryatides, or Caryatic Order.

Fig. 4, 5, & 6. The solecism in architecture of which we have now to speak has but the one existing example in the works of the Greeks, to which we have already referred. It is the third portion of the triple temple in the Athenian Acropolis, and is a projection from the flank of the principal Ionic structure, formed by a stereobatic dado raised on the stylobate and antæ-base mouldings of it, with a surbase consisting of a carved bead and carved ovalo corbelling a broad lintel, with a narrow projecting fillet above it. On this rests a square plinth, which bases a draped female figure, on the head of which there is imposed a circular moulded block, with a deep rectangular abacus, two thirds of whose face is vertical, and the other third is a cavetto, fillet, and small cyma-reversa. The stereobate, including the moulded base of the temple, is about three fourths the height of the statue-pillar with its base and capital. The entablature is rather less than two fifths of the same, but it consists of architrave and cornice alone, between which parts the height is nearly equally divided. Rather more than one fifth of the former is given to a carved bead and carved cyma-reversa, with the flat, plain cavetto and fillet which they corbel; the other four fifths are divided nearly equally into three fascias, of which the third or upper one has a fraction more than the other two, and is studded with plain circular tablets, whose diameter is five sixths of its depth. The cornice consists of bed-mouldings, corona, and crown mouldings. Two fifths of its whole height is given to the bed-mould, to which one seventh of that may be added for the portion cut up in the planceer. Half that increased height is occupied by a dentilled member, and the other half by a broad plain fillet, a carved bead, carved cyma-reversa, and a narrow fillet above it. The remaining three fifths of the whole cornice being again divided into five parts, rather less than two of them is given to the corona; a little more than one to a plain cyma-reversa and fillet, of which the latter is the wider; and of the rest a carved ovalo occupies five sevenths, and a listel or crowning fillet, with a carved bead on it, the other two. A pier, pilaster, or antæ, projects from the wall of the greater temple, and receives the end of the entablature behind the inner figure; for the projection is of two statues and their interspaces. It does not, however, rest on the stereobate, but runs down to the base-mouldings of the temple, the dado and surbase abutting against it. The antæ is capped by a congeries of carved mouldings, which support a narrow cavetto and fillet: the height of the cap is half the diameter of the antæ. There is also a hypotrachelium, consisting of a carved bead and the honeysuckle ornament, occupying about one third of a diameter in height. This Caryatidean portico displays very clearly the arrangement of the ceiling, with its coffers or cassoons. Internally the architrave is plain two thirds of its height; of the remaining third rather more than one half is a plain, slightly projected fascia; and the other is occupied by a carved bead and ovalo. In the absence of a frieze, the ceiling rests on this, and is divided by carved beads into panels, which are deeply coffered, and diminished by three horizontal moulded fascias.

Caryatic Order.

Of Grecian Mouldings and Ornament.

Pl. LXI. Greek architecture is distinguished for nothing more than for the grace and beauty of its mouldings; and it may be remarked of them generally, that they are eccentric, and not regular curves. They must be drawn, for they cannot be described or struck; so that though they be called circular, or elliptical, it is seldom that they are really so: not but that they may be, but, if they are, it is evidently the result of chance, and not of design. Hence all attempts to give rules for striking mouldings are worse than useless, for they are injurious: the hand alone, directed by good taste, can adapt them to their purpose, and give them the spirit and feeling which renders them effective and pleasing.

Grecian Mouldings.

The leading outline of Greek moulding is the gracefully flowing cyma. This will indeed be found to enter into the composition of almost every thing that diverges from a right line; and even combinations of mouldings are frequently made with this tendency. It is concave above and convex below, or the reverse; and though a long and but slightly flected line connect the two ends, they will always be found to correspond; that is, the convexity and the concavity will be in exactly the same curve, so that if the moulded surface were reversed, and the one made to assume the place, it would also have the appearance, of the other, and the effect would be the same. It is, in fact, the Hogarthian line of beauty; and it is not a little singular that Hogarth, in his well-known *Analysis of Beauty*, although he did not know, and indeed could not have known, the contours of Greek architectural mouldings, has given the principle of them, and, under his line of beauty, has described many of the finest Greek forms. The Roman and Italian mouldings were called Greek in his day, and he assumed them to be so; but they evidently do not agree with his theory, whereas, in principle, the now well-known Greek forms do most completely.

The cyma-recta is generally found to be more upright and less deeply flected than the cyma-reversa; it is almost always the profile of enrichments on flat surfaces, of foliage, of the covering moulding of pediments, of the undercut or hooked mouldings in antæ-caps, the overhanging not affecting the general principle; and it pervades, as we have said, flected architectural lines generally, whether horizontal or vertical. The cyma-reversa has all the variety of inflection that its opposite possesses, but the line connecting its two ends is, for the most part, more horizontal, and its curves are deeper. It pervades many architectural combinations, but is most singularly evinced in the composition of the Greek Doric capital, which is a perfect cyma-reversa, with the ends slightly but sharply flected, as it flows out of the shaft below, and turns in under the abacus above. The obviousness of the former is prevented by the annulets which divide the cyma into an ovalo and a cavetto, but the principle is clear.[1] The cyma is the governing outline in the congeries of mouldings in bases also, as may be noticed in the Ionic and Corinthian examples quoted and referred to.

Pl. LVII. & LVIII. Fig. 6 & 7.

Pl. LIX. Fig. 5. Pl. LX. Fig. 3.

An ovalo is but the upper half of a cyma-reversa, even when it is used as a distinct moulding, and unconnected with the waving form. Its name expresses its apparent rather than its real tendency; for its contour is not that of an egg in any section, though the ornament which is carved on it, when used as a running moulding, is formed like an egg; and from that it was named.

Pl. LXI.

The upper torus of a base forms, with the escape or apophyge of the shaft, a perfect cyma, and the scotia and lower torus do the same; so that the torus and scotia are referable to the same principle when in composition, and they are not found together except in the combination referred to.

The bead is an independent moulding, varying in contour; but it is generally the larger segment of a circle. It is used, however, sometimes to mask the waving form, and sometimes to separate it.

The cavetto, or simple hollow, is part of a cyma also, as we have shown; but it is also applied independently, to obviate a sharp angle, or to take from the formality of a vertical line, as in the abaci of Ionic antæ-caps. Its form, nevertheless, is not the segment of a circle, for the upper part of a cavetto is the most flected, and it falls below almost into a straight line.

Grecian Moulding

There is a hooked moulding common in Greek architecture, particularly in the Doric antæ-caps, which is technically called the hawk's-beak. It is a combination of curves which cannot be described in words; but it has been already referred to in speaking of the cyma-recta, which is brought into its composition.

Pl. LVII Fig. 5 & 1

Pl. LVII Fig. 5 & 1

The cyma-recta is never found carved, or sunk within itself; but it sometimes has the honeysuckle, or other ornament of the kind, wrought on it in relief, particularly when used as the covering moulding—the cymatium—of a pediment. The enrichment of the cyma-reversa consists of a contrasted repetition of its own contour meeting in a broad point below, and joining by a circular line above, and making a sort of tongued or leafed ornament, whose surface is inflected horizontally also. Between the leaves a dart-formed tongue is wrought, extending from the circular flexure above to the bottom of the moulding, whose contour it takes in front alone. As this would not mitre or join well on the angles of the cyma, a honeysuckle is gracefully introduced in the manner shown in the example. This enrichment is not wrought in relief on the moulding, but is carved into it, so that the surfaces of the parts of the ornament alone retain the full outline of the cyma. The ovalo is enriched with what is called the egg and dart ornament. This will be best understood by reference to the example. Its angles also are made with a honeysuckle, and the inflections are made in the moulding itself. The torus is sometimes enriched with the interlaced ornament called the guilochos: this too is cut into the moulding itself. We have no Greek example of an enriched scotia, and from its form and position, which, to be effective, must be below the eye, it hardly seems susceptible of ornament which could operate beneficially. The bead is carved in spheres or slightly prolate spheroids, with two thin rings or buttons, dilated at their axes, placed vertically between them. A cavetto is not enriched at all, nor is the hawk's beak, except by painting, which does not appear to have been an uncommon mode of enriching mouldings among the Greeks; that is, the ornament was painted on the moulded surface instead of being carved into it. Fascias are also found enriched by painted running ornaments, such as the fret or meander, the honeysuckle, and the lotus. Sometimes plain colour was given to a member, to heighten the effect it was intended to produce. Ornaments were painted and gilt on the coffered panels of ceilings too.

Pl. LXI.

The few examples which exist of sculptured ornament on straight surfaces exhibit varieties of nearly the same combinations as those last mentioned,—the honeysuckle with the lotus, and sometimes a variety of itself on scrolls, either throwing out tendrils, or plain. This is found on the necking of the Ionic columns of the Athenian Acropolis, and on those of their antæ, and continuing along under the congeries of mouldings, as previously described. The varieties of foliage used in the enrichments of Greek architecture are few, and will be found generally exemplified in the Corinthian capital of the choragic monument of Lysicrates, and in the rich acroteral pedestal or stem of the same edifice, than which we possess no more elaborate specimen of foliate enrichment of the Greek school. There exist many specimens of architectural ornament on vases and fragments, in marble and terracotta,

Pl. LX Fig. 3. Fig. 1.

[1] The presence of the cyma in the Doric capital was, we believe, first pointed out by Mr T. L. Donaldson, in the supplementary volume to the new edition of Stuart's *Athens*, though the true contour of the cyma itself appears to have escaped that gentleman's attention.

Roman Structures.

in which human figures, both male and female, are composed, with a greater variety of foliage than is generally found in Greek architectural works; and many of the beautiful marble and bronze utensils discovered in Herculaneum and Pompeii have enrichments obviously of Greek origin, from which, as well as from the specimens of ornament on positive architectural monuments, we may judge of their productions generally, as well as acquire or imbibe somewhat of the fine taste which originated them.

It would be puerile to speculate on the domestic edifices of the Greeks any further than we have done, as we possess no genuine data on which to proceed. Their sacred structures have taught us their style of architecture; but for its application to general purposes we have no resource but to consult the Roman remains of the exhumated Campanian cities and other places, and gather from analogy what Greek domestic architecture was.

Of Roman Structures.

Temples and other public buildings.

With a treatise on Roman architecture by a Roman architect, in our hands, mere transcription would appear to be all that is necessary in writing on the subject. But finding that author and existing specimens at variance, we cannot help determining in favour of the superior authority of the latter, to which, therefore, we shall refer to elucidate Roman edifices and the Roman style, as we did to the Greek remains to elucidate the Grecian.

Though far inferior in simplicity and harmony to the columnar architecture of the Greeks, that of the Romans, whether derived from it or not, is evidently of the same family, and is distinguished by boldness of execution and elaborate profusion of ornament. The tastes of the two nations are exemplified in the Doric of the former Pl. LII. and the Corinthian of the latter; the one a model of Pl. LII. simple grandeur, perfect in its peculiar adaptation, but almost inapplicable to any other purpose; and the other, Pl. LII. less refined, but more ornate, making up in extrinsic what it wants in intrinsic beauty—imperfect in every combination, but almost equally applicable to every purpose. As in Greece, so also in Rome, the noblest specimens of columnar architecture are in the temples of the divinity; but it does not appear that the Romans were in the habit of constructing them peripterally, as the Greeks so constantly did. There are indeed ruins which induce the belief that they at times built dipteral temples; but their common practice (as far as existing examples are authorities) was to make them pseudo-peripteral, or apteral and prostylar: of an amphiprostyle, even, we have not an example. It certainly is the custom to restore the ruined temples; whose remains are a few columns only, as if they had been peripteral; but it is done not only without sufficient authority, but against that which the more perfect structures present. The great projection, too, that the Romans gave their porticoes, is evidence that they were dependent entirely on themselves for effect; for they are generally projected three columns and their interspaces before the cella, which, however, has no pronaos with columns in antis; nor does it appear from existing remains that the Romans were accustomed to use that arrangement. Circular or peristylar temples are not uncommon in Roman architecture; and there are temples to which it can hardly be supposed that columns were ever attached: these are for the most part polygonal. Neither do the Romans appear ever to have constructed hypæthral temples with columns internally, as the Greeks did. Indeed it is a question whether all their temples were not cleithral; for it is not generally admitted that the Pantheon, which is hypæthral by the open eye of the dome, was originally a temple; and where the structures remain tolerably perfect, the ceilings and roofs appear to have been formed by arching from flank to flank, and thereby quite inclosing them.

Roman Structures.

The application of columns internally is most strikingly Pl. LXIV. effective in the Pantheon, where they are arranged in Fig. 4 & 5. front of niches, or deep recesses, composed with antæ to carry a crowning entablature round under an attic on which the cupola rests. No representation can convey even the most incompetent idea of the effect of this arrangement, to those who cannot gather it from the plan. A section presents only one compartment correctly; all the rest must of necessity be foreshortened. It is far otherwise with the temple of peace and the hall of the baths of Diocletian, in which columns stand before the piers to have the entablature broken over them. This, indeed, was the result, as we have before intimated, of the combination of columns with arches; and it is most clearly exemplified in those works which most probably originated the practice, and which are next in pretence to the temples:—these are the triumphal arches.

The Romans had not adopted the simple graduated stylobate of Greek columnar architecture in their temples, but made the access to their porticoes in front with thin Fig. 6, 7, & steps, and built vertical stereobates along the flanks for 8. the walls of the cella, or as stylobates, if there were attached columns. In applying a columnar arrangement to Fig. 10 & the triumphal arch, this lofty stylobate was taken also. 11. The breadth of the opening prevented the columns from being placed equidistant; they were, therefore, coupled, the entablature was broken over them, and necessarily the stylobate was cut through, leaving mere attached pedestals to stilt the columns, so that the whole ordinance was deprived of every thing that could render it as a composition beautiful: its simplicity and harmony were entirely gone; and instead of giving a graceful character to the structure, it became a mere attached frontispiece, that could only deform it. As if conscious that the Corinthian was too beautiful to maltreat in such a manner, the Roman architects produced the hybrid, which has since been called the Composite order, to use in these compositions: Pl. LXIII. in them, indeed, it is chiefly found; and if it were not Ex. 2. evidently a mere deterioration of the Corinthian, it might with truth and propriety be called the Roman order.

Coupled columns, broken and recessed entablatures and pedestals, and the Composite order, are among the greatest blemishes in Roman architecture; for the misformed and inappropriate abortions which have obtained the name of Ionic and Doric, in Roman works, are hardly Ex. 3 & 4. to be attributed to the school, but to individuals of it, as they are of very infrequent occurrence, and generally appear only in works which are otherwise ungainly. Such are the amphitheatres, whose elliptical forms can never be graceful, and whose architecture was invariably the worst the time produced. The immense structure in Pl. LXIV. Rome, which, from its magnitude, has been called the Fig. 1. Colosseum, bears in relief the gross architectural solecism of columns in stories, which, moreover, have recessed stylobates and immense intercolumniations, with large arches in them, which again reduce the effect of the column still more, making the continuity of the entablatures themselves a fault, by their consequent infirmity. The architectural details of this structure are coarse and inelegant, plain without simplicity, and laboured without elegance. But internally these blemishes disappear, columns and arches piled upon columns and arches give way to the long continuous lines which graduated from the arena to the gallery, and must have produced as grand an effect as almost any object in architecture: its magnitude and ruined state produce the imposing effect so striking at the present time; but the mind can easily restore it, or it may

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be contemplated in miniature in the amphitheatre at Verona.

The most perfect specimens of the Roman theatre remaining are those of Pompeii and Herculaneum. Like those of the Greeks, they, too, rest on the side of a hill; but instead of being hewn, they are built in it, as there is no rock out of which they might have been excavated. Their general form, however, is very similar to that of the Greek theatre, but they received a greater degree of architectural decoration than the latter was susceptible of. Of this the theatre of Marcellus in Rome is an example; for though otherwise destroyed, its external wall remains, and presents columnar ordinances, with intervening arches in stories, according to the vicious and inelegant practice of the Roman school. This, however, is on a plain, and presents external walls, which other examples do not so completely.

The baths of the Romans were structures of immense extent, and of splendid appearance internally. What their exteriors were we have no competent means of determining; fragments, however, give us reason to believe, that in architectural merit they did not surpass the exteriors of the amphitheatres. The walls internally were covered with stucco, and painted with foliage, figures of animals, and compositions, architectural landscape or history: the floors were of mosaic, laid in compartments, and variously ornamented: the ceilings were vaulted and stuccoed like the walls; sometimes they were enriched with coffered panels containing sculptured flowers or other architectural ornament, and sometimes they were merely painted with what are termed arabesques. Columnar ordinances do not appear to have been much used, and when they were, it was not always with good taste, as we have had occasion already to remark; though the structure called the Pantheon, which, with a great show of probability, is believed to have been a saloon in the baths, perhaps of Agrippa, on the contrary presents a beautiful adaptation of one. That the Pantheon was part of a more extended edifice, is very clear from its external form and appearance, which are unsightly in the extreme, presenting a mis-shapen and unfinished mass. Now, domed chambers are very common in the baths and palaces of the Romans. They are not only more effective than rectangular apartments, but were much more convenient in the absence of glass; for a small opening left in the apex lights and ventilates the vaulted saloon most completely, whilst the rain that could pass through it was necessarily small in quantity, and could be easily avoided by those walking on the floor. In rectangular vaults this could not be effected, so that rooms of that form depended on lateral openings for light and air, and were thereby exposed and uncomfortable. Again, there is a rectangular portico attached to the Pantheon, having no single feature in common with it, the former being a noble Corinthian octaprostyle of three intercolumniations projecting, with two others of antæ and pilasters behind; and the other a polygonal, bulbous mass of brickwork, much loftier than the portico, having cornices and blocking courses, too, none of which range with the entablature or any part of it. A conclusive argument, moreover, against the commonly received opinion, that the portico and the circular temple are an original composition, proving indeed that the former was an adaptation of what most likely had previously existed elsewhere in a different situation, and of course could not be intended for its present adjunct, is, that it now fronts north, and consequently the sun never shines full on it, so that it is in fact always in shadow; and that was never permitted by the ancients in their original compositions; for two thirds of the beauty of a portico, consisting in the beautiful play and contrast of light and shade it affords, are thus sacrificed. But in an after-appropriation, as we imagine in this case, it might have been, and clearly was done; probably through ignorance, as well as bad taste, in those who did it. If, then, the Pantheon, whose diameter is nearly 150 feet, was but an apartment—suppose the grand saloon or xystum—in the baths, the whole structure must have been immense; and if its proportions and internal architecture be taken, as they certainly may be, as a specimen of the style and manner of the interior of the edifice generally, we shall obtain a very high opinion of the magnificence of the Roman baths or thermæ. That they were adorned with admirable works of sculpture, too, is proved by the fact, that some of the noblest specimens of that art have been discovered in and among the ruins of the baths in Rome. It may be further remarked of the Pantheon, that its effect has been seriously injured since its original construction, by the removal of the columns from the recess opposite to the entrance, making the opening greater, fixing the columns before the antæ with the entablature broken round them, and turning an arch over the whole; thus destroying, as far as that part could affect it, the simplicity and perfect harmony of the primitive composition. The same bad taste which dictated that alteration affixed little pedimented excrescences, now used as altars, against the piers which alternate with the compartments of columns.

Fig. 2 & 3.

Fig. 4 & 5.

Palaces and villas

The still extensive remains of the villa of Adrian, near Tivoli, bespeak its original magnificence; and the architectural fragments with which the site even now abounds, though it has furnished specimens to almost every country in Europe, after having suffered the spoliation and destruction attending the incursions of barbarians and the lapse of so many centuries, attest its pristine beauty, and the fine taste of its imperial builder. This, however, furnishes no evidence that its exterior was attractive. Every thing about it appears directed to internal splendour and effect alone; and indeed all collateral evidence tends to the same point, that the exterior of Roman palaces and mansions was not heeded, being merely plain brick walls. This is the case at Pompeii, as we shall see; and the ruins of mansions in various parts of Italy, from that of Sallust on the Benacus or Lago di Garda, to those of other Roman nobles on the shores of the Bay of Baiæ, present no indications whatever that their exteriors were subjected to architectural decoration. The palace of Diocletian at Spalatro, and the splendid remains of Balbec and Palmyra, some of which perhaps belonged to secular structures, offer evidence to the contrary of this, if they are correctly restored in the works which treat of them; for they present in their elevations so many of the worst features of the Italian school, that there would be room for doubt, if views of the ruins did not help to bear the restorers out. But this does not appear to have been the case in the earlier ages of the empire, when architecture among the Romans was in its best state. Notwithstanding the extent of the structure, and its general magnificence, however, the mouldings and ornaments in the interior of the villa of Adrian, though in themselves classical and elegant, are small, and have a general air of littleness, especially when compared with the apartments to which they belong;—not that the apartments are generally large, but they are for the most part lofty. The ceilings appear to have been formed by vaulting; there are no indications of windows, and none of stairs of any magnitude—so that the rooms must have been nearly if not quite open at one end, to admit light and air; and the probability is that there were no apartments above the ground floor, though it is likely enough that terraces formed on the vaulted roofs were used for the purposes of recreation and pleasure. The floors were of mosaic, several of

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which are preserved entire in the Museum of the Vatican; and many fine specimens of ornamental sculpture in vases and candelabra, besides busts, statues, and groups in bronze, marble, porphyry, and granite, of various styles, the remains of the noble collection Adrian made during his progress through his extensive dominions, found among the ruins of the villa, are conserved in the same place.

The ruins of the palace of the Cæsars present no forms or arrangements from which it would be possible to form a rational notion of its original plan, still less of its general elevation, or indeed of the elevation of any part of it. Large vaulted apartments, with here and there a little stucco, sometimes moulded and sometimes plain or painted, and a few small unconnected chambers scattered up and down in a mountain of brick and rubble, convey too vague an idea, or rather they are incompetent to convey an idea of a palace at all.

If evidence were required to prove the futility of written descriptions of buildings when their general model is unknown, it would be enough to compare the house of a Roman gentleman in Pompeii with the various designs which have been made of the same thing from the descriptions and directions of Vitruvius, before the exhumation of that city. Their authors could only work upon the notion they had of laying out houses; and therefore the plans produced are those of ill-contrived modern residences, so arranged that they may present a uniform and architectural external elevation, which the Roman houses have not; with windows properly lighting every apartment, which are totally wanting in the latter; with staircases to upper stories that did not exist; with corridors and doors uniformly disposed, which was unheeded in laying out a Roman house. The Vitruvian restorers put columns wherever they could, whereas the Roman architects appear only to have put them where they could not avoid it. In dimensions, too, the former erred no less than in distribution; they thought none too extensive for a Roman domicile: but the apartments in Roman houses, wherever they are, are generally small, and in ordinary cases their whole site is exceedingly restricted. In proportioning the various parts, they adhered to rules the Romans never heeded; and applied the details of the architecture of temples and triumphal arches to domestic edifices, in whose composition the plasterer, painter, and mason, almost appear to have been the only architects!

Far inferior as Pompeii was to Rome in magnitude and splendour, there is no more reason for supposing that houses in the latter were so very differently arranged from those in the former that the same general description of them should not apply to both, than there would be for a future antiquary to hesitate in applying the plan of a Brighton or Bath house, which may be preserved, to a London mansion; for we know that in ordinary cases they nearly coincide. It is, too, a recorded fact, that wealthy Roman citizens had mansions at Pompeii and Herculaneum; and we have already stated that discoveries made of ordinary houses under the present level of Rome show them to be exactly like the more perfect ones of the Campanian city, except in their state of preservation; so that, "*parvis componere magna*," in Pompeii we may see the domestic as well as public architecture of ancient Rome.

The streets of Pompeii are very narrow, their average width being not more than twelve or fifteen feet; frequently they are not more than eight feet wide, and very few in any part exceed twenty. The principal excavated street in the city, that leading from the Forum to the gate towards Herculaneum and the street of the tombs, is, at the widest, twenty-three feet six inches, including two footways, each five feet wide. The streets are all paved with lava, and almost all have side pavements or footways, which, however, are for the most part so narrow, that, with few exceptions, two persons cannot pass on any of them. That the cars or carriages of the inhabitants could not pass each other in most of the streets, is proved by the wheel-ruts which have been worn on the stones, and the recesses made here and there for the purpose of passing. Their narrowness and inconvenience are aptly exemplified in London by the narrow lanes which come between St Paul's and Thames Street, about Doctors' Commons. The Forums, on the contrary, though not very spacious, are of regular forms, and have wide and convenient footways, completely colonnaded. In immediate connection with them are the theatres, the principal temples, the basilica, the courts of justice, and other public edifices: the amphitheatre is by itself, in an extreme angle of the city. The use of some of the buildings on one flank of the great Forum is not obvious: they are not arranged like temples, and indeed possess no peculiar character by which they may be distinguished: it is tolerably clear, however, from circumstances, that they were for the use of the public. The temples differ but little from the ordinary Roman structures of that description, but are generally inferior to them in the quality of the materials of which they are constructed, in the style of their architecture, and in the manner of its execution. The basilica is not unlike a modern church, it being a long rectangular edifice, having an arcaded porch at one end, being divided internally by rows of columns into nave and aisles, and having a columned recess at the west end of the nave for a tribunal. There are, however, no indications of windows, so that it was probably hypæthral, though that arrangement would have made the place very inconvenient for its purpose.

The streets of Pompeii are lined on either side with small cells, which served for shops of various kinds; and they are strikingly like the ordinary shops in towns in the south of Italy and in Sicily at the present time. Like them, too, there appear in very few cases to be accommodations in connection with the shops for the occupiers and their families, who must have lived elsewhere, as modern Italian shopkeepers very commonly do. These present no architectural decoration whatever; the fronts are merely plain stuccoed brick walls, with a large square opening in each, part of which is the door, and part the window, for lighting the place and showing the goods. Pl. LXV.

Houses and domestic accommodations.

Whenever a private house or gentleman's mansion occurs in a good place for business, like the ground floor of many modern Italian noblemen's palaces, the street-front, or fronts, was entirely occupied with shops, a comparatively narrow entrance being preserved to the house in a convenient part between some two of them. The door to this is sometimes quite plain, but at times it is decorated with pilasters. When the site permitted such an arrangement, the entrance door being open, a passer by could look completely through the house to the garden, or, in the absence of a garden, to the extreme boundary wall, on which was painted a landscape or other picture. An arrangement, it may be observed, not unlike this, is common in some of the Italian cities at the present day; but the mansions being now built in stories, and the upper stories alone being occupied by the families, a merely pleasing effect is produced; but in the former, persons crossing from one apartment to another were exposed, and domestic privacy thus completely invaded to produce a pretty picture. Within the entrance passage, which may be from ten to twelve feet in depth, there is a vestibule or atrium, generally square, or nearly so, on which various rooms open, that vary in size from ten feet square to ten feet by twelve, or even twelve feet square: they

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have doors only, and were probably used as sleeping-chambers by the male servants of the family. In the centre of this court there is a sunk basin or reservoir for receiving the rain, called the compluvium, rendering it likely that this was roofed over, with a well-hole to admit light and air, and allow the rain to drop from the roof into the reservoirs. Connected with this outer court was the kitchen and its accessories. If the site allowed the second court to be placed beyond the first in the same direction from the entrance, the communication was by a wide opening not unlike folding doors between rooms in modern houses, generally with a space intervening, which was variously occupied; if the site did not allow of that arrangement, a mere passage led from one to the other. The second or inner vestibule, atrium, or court, is generally much larger than the first, is for the most part parallelogramic, but variously proportioned. It forms a tetrastoön, being open in the middle and arranged with a peristyle of columns, colonnading a covered walk all round. On this the best and most finished apartments open; but they are of such various sizes, and are so variously arranged, that it is not easy to determine more than that they included the refectory, the library, and sleeping-rooms. Some of them, indeed, are such as must have been useless except for the last purpose: these, perhaps, were the apartments of the female branches of a family, at least in most cases. Some houses, however, have a nest of small cells in an inner corner or secluded recess, which may have been the Gynæceum; but that is far from being common. Exhedræ or recesses, open in front to the atrium, are common, and are often painted with more care and elegance than any other part of the house; but generally the walls are everywhere painted—in the more common places flat, with a slight degree of ornament perhaps, and in the best rooms with arabesques and pictures in compartments. The architectural decorations are mostly painted: the ornaments are not unfrequently elegant, but the architecture itself of the mansions is bad in almost every sense. The rooms being windowless, would, when covered, be necessarily dark; the doors are arranged without any regard to uniformity, either in size or situation. The street-fronts of those houses which, not being in a good business situation, were not occupied with shops, were not merely unadorned, but were actually deformed by loop-holes to light some passage or inner closet which had no door on one of the courts. The columns of the second courts are generally in the worst style possible: those which have foliated capitals, and may be considered compositions of the Corinthian order, are the best; but the imitations of Doric and Ionic are both mean and ugly. From the duty they had to perform, and the wideness of their intercolumniations, together with the fact that none of them remain, it is probable that the entablatures were of wood, and were consequently burnt at the time of the destruction of the city, and broken up by the inhabitants, almost all of whom certainly escaped, and who, it is very evident, returned, when the fiery shower and the conflagration had ceased, to remove whatever they could find of their property undestroyed; for it must be remembered that the roofs and ceilings all over the city are entirely gone, and the uncovered and broken walls remain, from eight to ten feet only in height. Every thing, indeed, clearly demonstrates that great exertions were used to recover whatever was valuable; and it is very probable, moreover, that the place was constantly resorted to by treasure-seekers for perhaps centuries after the calamity occurred. It may also be remarked that the loftier edifices, which would have been unburied by the ashes, had been thrown down by a terrible earthquake about sixteen years before the volcanic shower fell, and therefore were the more easily covered. Other showers must have fallen since that which destroyed the city, to produce the complete filling up of every part and the general level throughout; as the one must have been prevented by those roofs and ceilings which were fire-proof in the first instance, and the other would be the result of the same, if it were not deranged by the subsequent excavations. It is indeed the fact, that the superstrata of ashes are evident and unbroken, while the substratum is mingled with ruins. Hence we are still uninformed as to the structure and disposition of the roofs and ceilings of the houses of the ancients. The doors, too, of whatever materials they were composed, are entirely gone: there remain, however, here and there, indications of wooden door-posts—in some cases, indeed, charred fragments of them—but they are to outer or street-doors, leaving it probable, as we have before suggested, that a matting of some kind, suspended from the lintel, formed the usual doors to rooms,—or perhaps they were closed by curtains only. In these particulars, unfortunately, Herculaneum affords but little assistance, as the mode of its destruction was similar to that of Pompeii, and it, too, was doubtlessly exposed in nearly the same manner; its subterranean situation, moreover, at present, renders it difficult to examine; but, upon the whole, Herculaneum is more likely to furnish information on these particulars than its sister in misfortune. Although it has been ascertained that the Romans understood the manufacture of glass, or at least that they possessed some utensils of that material, it must not be supposed that they were accustomed to apply it to exclude the weather and transmit light; for in no case has a glass window of any kind been discovered in any ancient structure; and, without contemplating the houses of Pompeii, it is impossible to appreciate the advantages we derive in our habitations from the application of that beautiful production of the useful arts, and how much superior it alone renders them to those of the ancients. The floors of the houses of Pompeii and Herculaneum are all of mosaic work, coarser and simpler in the less esteemed parts, and finer and more ornate in the more finished apartments: the ornaments are borders, dots, frets, labyrinths, flowers, and sometimes figures. In this, too, the superior advantages the moderns enjoy are evident. The ancients did not understand how to construct wooden floors, at least the application of timber to that use was not made by them; for, though it were admitted, which, however, it cannot be with justice, that, in the warmer climate of the south of Italy, lithic floors would be more grateful, that would not be the case in this country; and we find the remains of Roman houses, baths, &c. in England, with floors of mosaic, as in Naples and Sicily. All the indications which are found in Pompeii of an upper story consist in a few rude and narrow staircases, which, it is very probable, were to afford access to the terraces or flat roofs, for they are not common, and no portion of an upper story remains in any part, though the lower or ground-floor rooms, it is most likely, were arched over. In one part of the city the houses on one side of a street are on a declivity: there a commodious flight of stairs is found to lead from the atrium in front, to another atrium and rooms below, not under the houses, but behind them; for neither do we find an under-ground or cellar story in the Pompeian houses. On the shores of the Bay of Baiæ, and of the Gulf of Gaeta, at Cicero's Formian Villa, however, there are crypts or arched chambers under the level of the mansions; for the sites require substructions; but it may be questioned whether even these were used as parts of the house, and as we use cellars; for they present no indications of stairs, and have no regular means of intercommu-

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nication. Neither had the houses of the Romans chimneys of any kind; their only mode of warming their apartments was by means of braziers, many specimens of which have been taken out of both Herculaneum and Pompeii; and their cooking fires were on fixed gratings over a sort of stove, but without flues; so that most probably charcoal alone was burnt for domestic purposes. In this respect the modern Italians are not far beyond their predecessors; and the mode used by them of applying fire in warming and cooking appears very similar to that used by the Romans. Indeed many of the peculiarities we have noticed in the Pompeian houses are still found in various parts of Italy and Sicily; the cortili, courts, or cloisters of palaces, mansions, monasteries, and inns, are representatives of the cavædia, vestibula, atria or courts, of Pompeian or Roman mansions. It is common, too, in the former, for bed-rooms to open on open galleries, as on the colonnaded courts of the latter. There are instances also in the countries referred to, of rooms which have no aperture but the doorway. Shops, we have said, are frequently mere cells, having an opening towards the street, part of which is a door, and the other part, with a low dado, a window. It was only in the forums and public places, then, that architectural beauty and magnificence were displayed in a Roman city. Street architecture was unknown, and the decoration of houses was the work of the plasterer and painter rather than of the architect.

If such as we have described were the imperfections and inferiority of the domestic architecture of the Romans, who knew that of the Greeks and Egyptians, and had, moreover, knowledge of the use of the arch, and were, we have reason to believe, better carpenters than either, besides possessing greater wealth, and a greater taste for luxury than they, with a less mild and serene climate than Greece and Egypt,—what must the domestic edifices of those nations have been! A person accustomed to the comforts and conveniences of houses in this country finds much to complain of in a modern Italian mansion, but not so much as an Italian would in the house of an ancient Roman; and from analogy we may believe that a Roman of the empire would have had reason to complain of a Grecian domicile, even of the Periclean age; and a Greek, again, might have been abridged of the comforts of his house in the palace of an Egyptian.

Superior as the habitations of civilized men in modern times may be to those of the ancients, a degree of classic beauty and elegance pervaded the decorations and furniture, and even the domestic utensils, in the houses of Pompeii and Herculaneum, which we do not equal, though we imitate them; and from the Hellenic taste which reigns in their forms and enrichments, their origin may generally be attributed to Greek artists; so that, it may be supposed, in these particulars the Greeks even excelled the Romans. It is indeed not a little singular, that though the architecture of these cities is completely Roman, the painted ornaments and ornamental sculpture generally are in style and manner perfectly Greek. There are certainly modifications found of Greek Doric columns in Pompeii; but they bear so slight a degree of relationship to their original, that its existence may almost be denied,—they have the form without the feeling.

Sepulchral monuments.

As works of architecture, the sepulchral monuments of the Romans were of more importance than their domestic structures. There is more architectural display in the street of the tombs at Pompeii, than in any street of the city itself; and the mausoleum of Adrian on the right bank of the Tiber at Rome was a much more important object in its perfect state than his villa near Tivoli could ever have been. It was perhaps the most splendid structure of the kind ever executed; excelling the Memphian pyramids as much in architectural pretence as they surpass it in magnitude. There was, too, a degree of harmony and simplicity in its composition, which can only be accounted for by supposing that the imperial builder, who was himself an adept in architecture, had acquired better taste than the architects of Rome generally possessed, by the contemplation of the monuments of Greece and Egypt. It consisted of a deep quadrangular basement, each of whose sides was about 250 feet in length. This was surmounted by a lofty circular mass, on which was a graduated stylobate, supporting a noble peristyle of Corinthian columns, with their entablature; forming, with its circular cone, a species of peristylar temple, something like that below the cupola of St Paul's Cathedral in London. Above this there was, most probably, a species of dome, whose acroterium is said to have been a metal pine-cone, which was the receptacle of the ashes of the emperor. The mausoleum of Augustus was inferior in size, in splendour, and in good taste, we may believe, from the descriptions which exist of it when in a more perfect state than it is at present, to that of Adrian; but it was nevertheless a magnificent monument. Its form was conical; it diminished in stories and terraces, probably columned round, and terminated at the apex in a bronze figure of its founder. The sepulchral monuments of Cecilia Metella, of the Plautian family, and others, are evidences of the same fact. The sarcophagus from the first-mentioned of these is simple and elegant in the extreme; and indeed it exhibits a greater degree of good taste than almost any thing of the same kind that remains to us of the ancients.

Roman Corinthian.

Of the Roman Corinthian.

Like the Greek orders, the Roman Corinthian may be said to consist of three parts, stylobate, column, and entablature; but, unlike them, the stylobate is much loftier, and is not graduated, except for the purposes of access before a portico. Its usual height is not exactly determinable, in consequence of the ruined state of most of the best examples; but it may be taken at from two and a half to three diameters. In the triumphal arches the height of the stylobate sometimes amounts to four, and even to five diameters. It is variously arranged, moreover, having, in the shallower examples, simply a congeries of mouldings forming its base, with perhaps a narrow square member under it, a plain dado, and a covering cornice or coping, on the back of which the columns rest. In the loftier examples a single, and sometimes a double plinth, comes under the base mouldings; and a blocking cornice superimposes the coping, to receive the bases of the columns. This last is only necessary when the height of the stylobate is such as to take the columnar base above the human eye, when the coping cornice would intercept it if a blocking cornice did not intervene. Pl. LXIV. Fig. 6, 8, 9, & 10.

The column consists of base, shaft, and capital, and varies in height from nine and a half to ten diameters. The base has, ordinarily, in addition to the diminishing congeries of mouldings which follows the circular form of the shafts, a square member or plinth, whose edges are vertical: with this the whole height of the base is about half a diameter. The rest of this part of the column is variously composed, but it generally consists of two plain tori and a scotia, with fillets intervening, as in the Greek examples of this order, but differently proportioned and projected, as the examples indicate. Sometimes the scotia is divided into two parts, by two beads with fillets, as in the Jupiter Stator example, in which also a bead is placed between the upper torus and the fillet of the apophyge. The spread of the base varies from a diameter and one third to a dia- Pl. LXII. Ex. 1.

Roman Corinthian.

meter and four ninths. In the best Roman examples, as well as in the Greek, the shaft diminishes with entasis: the average diminution is one eighth of a diameter. The shaft was always fluted when the material of which it was composed did not oppose itself; for the Romans often used granites, and sometimes a stratified or laminous marble called *cipollino*, for the shafts of columns; the former of which could not be easily wrought and polished in flutes, and the latter would scale away if it were cut into narrow fillets. Like the Greek Corinthian and Ionic orders, the Roman Corinthian has twenty-four fillets and flutes. The flutes are generally semicircles, and they terminate at both ends, for the most part, with that contour. Dividing the space for a fillet and a flute into five parts, four are given to the latter, and one to the former. The hypotrachelium is a plain torus, about half the size of the upper torus of the base, or half the width of a flute, as these nearly correspond: it rests on a fillet above the cavetto at the head of the shaft.

The ordinary height of the capital is a diameter and one eighth; but there is a very fine example in which it hardly exceeds one diameter, and another in which it is not quite so much. It is composed of two rows or bands of acanthus leaves, each consisting of six, placed upright, and ranged side by side, but not in contact; of helices and tendrils trussed with foliage; and an abacus, whose faces are moulded and variously enriched. The lower row of acanthus leaves is two sevenths the whole height of the capital; the upper row is two thirds the height of the lower above it, and its leaves rest on the hypotrachelium below, in the space left between the others. They are placed regularly, too, under the helices and tendrils above, which support the angles, and are under the middle of each side of the abacus. The construction and arrangement of the next compartment above must be gathered from the examples; for an idea of them cannot be conveyed in words. The abacus is one seventh of the height of the capital; in plan it is a square whose angles are cut off, and whose sides are concaved in segments of a circle, under an angle at the centre of from 55° to 60°. Its vertical face is generally a flat cavetto, with a fillet and carved ovalo corbelling over at an angle of about 125°. The cavetto is sometimes enriched with trailing foliage, and a rosette or flower of some kind overhangs the tendrils from the middle of each side of the abacus.

Every example of this order differs so much in the form, proportion, and distribution of the various parts, of its capital particularly, that it cannot be described in general terms, like the Greek Doric and Ionic: the example we have referred to in this definition is that of the Jupiter Stator, the most elegant, perhaps, of all the Roman specimens. Ex. 1.

The entablature varies in different examples from one diameter and seven eighths to more than two diameters and a half in height. Perhaps the best proportioned are those of the portico of the Pantheon, and of the temple of Antoninus and Faustina; the former being rather more than two diameters and a quarter, and the latter rather less than that ratio. The entablature of the temple of Jupiter Stator is more than two diameters and a half in height, of which the cornice alone occupies one sixth more than a full diameter, leaving to the frieze and architrave something less than one diameter and a half between them. In this latter particular it nearly agrees with the other two quoted examples, so that the great difference in the general height is in the cornice almost alone, the cornices of the others being about a sixth less, instead of as much more, than a diameter in height. The Roman Corinthian entablature may be taken, then, at two diameters and a quarter in height. Rather more than three fifths of this is nearly equally divided between the architrave and frieze, the advantage, if any, being given to the former; the cornice, of course, takes the remaining two fifths, or thereabouts. The architrave is divided into three unequal fascias and a small congeries of mouldings, separating it from the frieze. The first fascia is one fifth the whole height; one third of what remains is given to the second, and the remainder is divided between the third fascia and the band of mouldings,—two thirds to the former, and one to the latter. A bead, sometimes plain and sometimes carved, taken from the second fascia, which is itself enriched in the Jupiter Stator example, marks its projection over the first; and a small cyma-reversa, carved or plain as the bead may be, taken from the third fascia, marks its projection over the second. The band consists of a bead, a cyma-reversa, carved or plain according to the general character of the ordinance, and a fillet. In non-accordance with the practice of the Greeks, the face of the lowest or first fascia of the architrave, in the Roman Corinthian, impends the face of the column at the top of the shaft, or at its smallest diameter; and every face inclines inwards from its lowest face up. The whole projection of the architrave, that of the covering fillet of the band, is nearly equal to the height of the first fascia. The frieze impends the lowest angle of the architrave. Its face is either perpendicular, or it slightly inclines inwards, like the fascias of that part of the entablature: in some cases it is quite plain, and in others is enriched with a foliate composition, or with sculptures in low or half relief. The cornice consists of a deep bed-mould, variously proportioned to the corona; but it may be taken generally, when it has modillions, at three fifths, and when it has none, at one half the whole height. It is composed of a bead, an ovalo or cyma-reversa and fillet, a plain vertical member, sometimes dentilled, another bead, and a cyma-reversa and fillet or ovalo, as the lower may *not* be: this is surmounted, when modillions are used, by another plain member, with a small carved cyma-reversa above it. On this the modillions are placed, and the cyma breaks round them. They are about as wide as the member from which they project, and are about two thicknesses apart. In form they are horizontal trusses or consols, with a wavy profile, finishing at one end in a large, and at the other in a small, volute; and under each there is generally placed a raffled or acanthus leaf. In proportioning the parts of this bed-mould in itself, one third of its height may be given to the modillion member, and the other two thirds divided nearly equally, but increasing upwards into three parts, one for the lowest mouldings, one for the plain or dentil member, and the third and rather largest portion for the mouldings under the modillion member. The mouldings of this part of the cornice are carved or left plain, according to the character of the ordinance; and its greatest projection, except the modillions themselves, that of the modillion member, is about equal to half its height. The upper part of the cornice,—the corona, with its crown mouldings,—consists of the vertical member called the corona, which is two fifths the whole height;—this, in the examples of the temples of Jupiter Stator and Antoninus and Faustina, is enriched with vertical flutes;—a narrow fillet, an ovalo, and a wider fillet, occupy one third of the rest, the other two thirds being given to cyma-recta, with a covering fillet which crowns the whole. Its extreme projection is nearly equal to the whole height of the cornice.

Ex. 4. Ex. 3.

The ordinance of the temple of Vesta, or of the sibyl at Tivoli, whose entablature is the very low one mentioned, is not generally in accordance with the scale we have given, and it must be referred to for its own peculiar proportions. Ex. 5.

Roman Corinthian.

Pediments with the Roman Corinthian order are found to be steeper than they were made by the Greeks, varying in inclination from eighteen to twenty-five degrees; but they are formed by the cornice of the entablature in the same manner. Antefixæ do not appear to have been used on flank cornices as in Greek ordinances, in which the cymatium is confined to pediments; but in Roman works it is continued over the horizontal or flank cornice, as we have described; and frequently it is enriched with lions' heads, which were at the first introduced as water-spouts. The planceer or soffit of the corona is, in the Jupiter Stator example, coffered between the modillions, and in every coffer there is a flower. The soffit of the entablature in this order is generally panelled and enriched with foliate or other ornament. The intercolumniation is not the same in any two examples. In the temple of Vesta in Rome it hardly exceeds a diameter and a quarter; in the Jupiter Stator example it is a fraction less than one diameter and a half; in that of Antoninus and Faustina, nearly a diameter and three quarters; in the portico at Assisi, rather more than that ratio; in the portico of the Pantheon, almost two diameters; and in the Tivoli example, a fraction more than that proportion.

The antæ of the Roman Corinthian order is generally parallel; but pilasters are mostly diminished and fluted as the columns. Of two of the existing examples of antæ, in one—that of the temple of Mars Ultor—they are plain, to fluted columns; and in the other—that of the Pantheon portico—they are fluted, to plain columns. The capitals and bases are transcripts of those of the columns, fitted to the square forms.

Ceilings of porticoes are formed, as in the Greek orders, by the frieze returning in beams from the internal architrave to the wall or front of the structure, supporting coffers more or less enriched with foliage or flowers. This, however, could only have been effected when the projection was not more than one, or at the most two intercolumniations, if stone was used; and it is only in such that examples exist. Porticoes ordinarily must have had arched ceilings, as that of the Pantheon has, or the beams must have been of wood; in which latter case probably the compartments of the ceiling would be larger. How, in the former, it was arranged we cannot tell, as the arches only remain; and they may not be of the date of the rest of the portico.

Pl. LXIII. Ex. 2. The ancient examples of what is called the Composite order do not differ so much from the ordinary examples of the Corinthian as the latter do among themselves, except in the peculiar conformation of the capital of the column. In other respects, indeed, its arrangement and general proportions are exactly those of the Corinthian. The Composite was used, we have said, in triumphal arches, and, in the best ages of Roman architecture, in them alone. The difference in the capital consists in the enlargement of the volutes to nearly one fourth the whole height of the capital, and in connecting their stems horizontally under the abacus, giving the appearance of a distorted Ionic capital. The central tendrils of the Corinthian are omitted, and the bell of the capital is girded under the stem of the volutes by an ovalo and bead, as in the Ionic. Acanthus leaves, in two rows, fill up the whole height from the hypotrachelium to the bottom of the volutes, and are consequently higher than in the Corinthian capital: this difference is given to the upper row. Besides this Composite, however, the Romans made many others, the arrangements and proportions of the ordinances being generally those of the Corinthian order, and the capitals corresponding also in general form, though in themselves differently composed. In these, animals of different species, the human figure, armour, a variety of foliage, and other peculiarities, are found. Shafts of columns also are sometimes corded or cabled instead of being fluted: those of the internal ordinance of the Pantheon are cabled one third their height, and the flutes of the antæ of that ordinance are flat, eccentric curves. There are fragments of others existing, in which the fillets between the flutes are beaded; some in which they are wider than usual, and grooved; others, again, whose whole surface is wrought with foliage in various ways; and it would be no less absurd to arrange all these in different orders, than it is to make a distorted foliate capital the ground-work of an order.

Roman Ionic.

Of the Roman Ionic.

The only existing example of this in Rome, in which the columns are insulated, is in the Temple of Manly Fortune, except that of the Temple of Concord, which is too barbarous to deserve consideration. Its stylobate, like that of the Roman Corinthian, is lofty and not graduated, having a moulded base and cornice or surbase. The column is nearly nine diameters in height; its base is half a diameter in height, and consists of a plinth, two tori, a scotia, and two fillets; the shaft has twenty fillets and flutes, and diminishes one tenth of a diameter; the capital is two fifths of a diameter in height; the volutes, however, dip a little lower, being themselves about that depth without the abacus; the corbelling for the volutes is formed by a bead and large ovalo, half the height of the capital; the latter of these is carved: a straight band connects the generating lines of the volutes, whose ends are bolstered and enriched with foliage; and a square abacus, moulded on the edges, covers the whole. The entablature is rather less than two diameters high; three tenths of this are given to the architrave, the same to the frieze, and the cornice occupies the remaining two fifths. The architrave is unequally divided into three fascias, and a band consisting of a cyma-reversa and fillet; the lowest angle impends the upper face of the shaft of the column. The frieze is in the same vertical line, and is covered with a fillet which receives the cornice; it is also enriched with a composition of figures and foliage. The cornice consists of a bed-mould, two fifths of its height, and a corona with crown mouldings. The bed-mould is divided nearly equally between a cyma-reversa and fillet, a square dentilled member and fillet, and another fillet and ovalo. The corona is two fifths the height of the rest of the cornice; another fifth is occupied by two fillets and a cyma-reversa, and the rest is given to a cyma-recta and crowning fillet. The whole projection is nearly equal to the height of the cornice. The cymatium is enriched with acanthus leaves and lions' heads, and the mouldings of the bed-mould and architrave band are carved. The soffit of the corona is hollowed out in a wide groove, whose internal angles are rounded off in a cavetto, but without ornament of any kind, forming indeed a mere throating. Like the angular capitals of the Greek Ionic, the external volute of this is turned out and repeated on the flank: either that or the abuse of it in the Composite capital gave rise to distortions of this order, in which all the volutes of the capital are angular, and consequently all its four faces are alike. In other respects, however, it does not differ generally from the ordinary Roman examples of Ionic. The Temple of Manly Fortune is pseudo-peripteral, and consequently has neither antæ nor pilasters, nor do ancient examples exist of either.

Pl. LXIV. Fig. 12.

Pl. LXIV. Fig. 12.

Of the Roman Doric.

This is even a ruder imitation of the Grecian original than the mean and tasteless deterioration of the voluted Ionic is of the graceful Athenian examples. The specimen of it which is considered preferable to the others is

Pl. LXIII. Ex. 4.

Roman Doric.

that of the theatre of Marcellus in Rome. The column is nearly eight diameters in height: it consists of shaft and capital only. The shaft is quite plain, except fillets above and below, with escape and cavetto; and it diminishes one fifth of its diameter. The capital is four sevenths of a diameter high, and is composed of a torus which forms the hypotrachelium, and, with the necking, occupies one third the whole height. Three deep fillets, with a semitorus or quarter-round moulding, are intended to represent the ovalo and its annulets of the Greek capital. They occupy three sevenths of the rest; the other four sevenths are given to the abacus, three fifths of whose depth is plain and vertical; and the other two are divided between a cyma-reversa and a fillet.

The corona and crown mouldings of the cornice being destroyed, the whole height of the entablature cannot be correctly ascertained; but from analogy it may be taken, with the bed-mould, part of which exists, at about two thirds of a diameter, making, with the architrave and frieze, an entablature nearly two diameters high. Of this the architrave is rather more than one fourth, indeed exactly half a diameter. Three tenths of its depth are unequally occupied by the tænia, regula, and guttæ, the first being rather the widest, projecting more than its own depth, and the second the narrowest. The guttæ are six in number, and are truncate semicones in form. The rest of the surface of the architrave is plain and vertical, impending a point rather within the superior diameter of the column. The frieze is two fifths the whole height of the entablature. A fascia, one eighth of its own height, bands it above the triglyphs, and projects about one third of its depth; the rest of its surface is plain vertically, but horizontally it is divided into triglyphs, which are half a diameter in width, and are placed over the centres of the columns. These are channelled with two full and two hemi-glyphs, whose heads are cut square on the outer edge, but inclined downwards at the angle of the glyphs. The space between the triglyphs is equal to the height of the frieze without its plat-band or fascia, making in effect perfectly square metopes. All that can be traced of the cornice is a small cyma-reversa, immediately over the frieze, and a square member with dentils on it. In the example the cornice is completed from that of the Doric of the Colosseum.

The temple at Cora presents a singular specimen of the Doric order, evidently the result of an examination of some Greek examples, but moulded to the Roman proportions and to Roman taste. The columns are enormously tall, but the shafts are partly fluted and partly chamfered for fluting, like the Greek. The capital is ridiculously shallow, but the abacus is plain, and the echinus of a somewhat Hellenic form. The entablature is very little more than a diameter and one third in height, and the architrave of it is shallower even than the capital; but the frieze and cornice are tolerably well proportioned, though the triglyphs in the former are meagre, narrow slips, and the latter is covered by a deep widely projecting cavetto, that would be injurious to even a better composition. Instead of regular mutules with guttæ, the whole of the planceer of the cornice is studded with the latter; but, like the Greek, the triglyph over the angular column extends to the angle of the architrave, which does not appear to have been the practice of the Romans; yet the reason for so doing does not appear to have been understood, for the external intercolumniations are the same as the others.

As far as we have the means of judging, the Romans made the antæ of their Doric similar to the columns, only that they were of course square instead of round; though indeed an attached column appears to have been generally preferred.

Roman Moulding.

It may, however, be here again intimated, that these two orders, the Ionic and Doric of the Roman school, ought hardly to be considered as belonging to the architecture of the Romans. They are merely coarse and vulgar adaptations of the Greek originals, of which we now possess records of the finest examples. If it were not, therefore, that custom required it, we should have omitted all mention of them, or at least have left them to the Italo-Vitruvian school, to which they properly belong. Yet their meanness and tastelessness, when compared with the Grecian models, will more strikingly show the superiority of the latter, and show, moreover, how the architects of the Italian school must have been blinded by their system, when they fancied such wretched exemplars as those of which we have been speaking to be beautiful.

Of Roman Mouldings and Ornament.

Pl. LX

The mouldings used in Roman architectural works are the same as the Grecian in general form, but they vary materially from them in contour. The Roman cyma-recta is projected much more than the Greek, with a deeper flexure; and the two parts or ends seldom correspond, the one being generally larger than the other. On the contrary, the Roman cyma-reversa does not project so much, or at so large an angle with its base, as the Grecian, nor is it so deeply flected as the Greeks made it. The upper or convex part of this moulding is almost always larger than the lower or concave; and it is frequently allowed to finish below in a sharp arris projecting from whatever may be below it, and above it abuts the horizontal soffit of its covering fillet in a similarly harsh manner. The ovalo of Greek architecture is represented in the Roman style by a moulding whose outline is nearly the convex quadrant of a circle, or a quarter round, and sometimes it is nearly that of the quadrant of an ellipsis. The Roman torus is either a semicircle or a semiellipsis; and the bead is a torus, except in its application, and in being smaller, and generally projected rather more than half the figure whose form it bears. The cavetto, in Roman architecture, is nearly a regular curve, being sometimes the concave quadrant of a circle, or indeed the reverse of an ovalo, and sometimes a smaller segment. A Roman scotia is more deeply cut, and is consequently less delicate than the same member in a Greek congeries: its form frequently approaches that of a concave semiellipsis.

This correspondence in general form, and disagreement in spirit, of Greek and Roman mouldings, appear to have arisen entirely from the ignorance or inattention of the Romans to the governing principle of Greek combinations; as we have seen that in these the individual mouldings are not independent, as the Romans made them, but that they take their contour and direction from each other, under a certain pervading outline.

The enrichments of Roman mouldings are for the most part similar to those of the Greek, but less delicate and graceful both in design and drawing. Those of the cyma and ovalo are particularly referred to, but the Romans used others besides. Raffled leaves form a favourite enrichment in the architecture of the Romans: indeed these are hardly less frequent in their works than the honeysuckle is in those of the Greeks. Mouldings were enriched with them; and a raffled leaf masks the angles of carved cymas and ovalos in the former, as a honeysuckle does in the latter. Nevertheless, the honeysuckle and lotus are both found in Roman enrichments, particularly the latter, and perhaps even more than in Greek. It is not uncommon to find examples of Roman architecture completely overdone with ornament,—every moulding carved, and every straight surface, whether vertical or

horizontal, sculptured with foliage, or with historical or characteristic subjects in relief. This fault is most obvious in those works which exhibit similar bad taste in the general composition. The triumphal arch of Septimius Severus, the little arch of the goldsmiths, and the half-buried ruin called the temple of Pallas, in the forum of Nerva at Rome, are egregious specimens. The entablature of the arch of Titus, too, is overloaded with ornament.

Frieze enrichments, consisting of foliage composed with animals, and a variety of other things, are very common in Roman architecture. Many specimens indeed are not found in existing structures, but there are numerous fragments of entablatures of destroyed edifices which exhibit them in great variety. Their general character is exuberance, and a tendency to frittering, from the variety and incoherence of form in their composition; but their effect can only fairly be judged of when seen in appropriate situations. One existing example of an enriched frieze of the kind referred to, that of the temple of Antoninus and Faustina, speaks strongly in its favour, for nothing can surpass its efficiency and simple beauty; but it must, moreover, be confessed that, when examined in detail, the enrichment is less exuberant, and is composed of fewer parts, than most others of the species to which that example belongs. Architectural ornament, however, is not confined to purely architectural works. We find many beautiful specimens of it on the vases and candelabra which decorated the baths and mansions of the ancient Romans, and whose elegance of form rivals even the beauty and delicacy of their enrichments. Whether these should be referred or not to the Romans, is doubtful; for it has been already intimated, from the style of many of them, both in outline and ornament, which appertain more to the Greek, that they are the productions of Grecian artists; but indeed they belong exactly to neither, for they frequently possess the beauties, and sometimes exhibit the defects, of both. There are existing works, too, clearly of Roman origin, and far inferior in every respect to the things just quoted. These are for the most part cenotaphial monuments, sarcophagi, and altars, whose composition, details, and enrichments, are gross and inelegant when compared with the objects alluded to. The difference may arise merely from the inferiority of the artists of the one to those of the other, and not from the difference of their schools; but the prevalence of Greek taste in the superior productions is not the less striking because it was acquired by education, while it is wanting in the inferior, whose authors had not been imbued with the spirit and fine feeling of the Greek style.

Of Italian Architecture.

Gothic architecture,—that is, the style which preceded the Pointed,—being for the most part a mere deterioration of Roman, and possessing no peculiar character which can recommend it as a subject for study and imitation that may not be deduced from the Roman style, and Pointed architecture being a genus *per se*, we have thought it better to allow the Italian, or revived Roman style, to usurp its chronological place; as the latter more naturally follows what it pretends to be derived from, than it would follow the Pointed, or than the Pointed would the Roman.

We have already stated that Italian architecture, though professedly a revival of the classical styles of Greece and Rome, was formed without reference to the existing specimens of either, but on the dogmas of an obscure Roman author, and the glosses of the "revivers" on his text. Vitruvius described four classes or orders of columnar composition; and, on the principles which governed him in subjecting to fixed laws all the varieties with which he appears to have been acquainted, they formed a fifth, of a medley of two of his, thus completing the Italian orders of architecture. The school which was founded on the Vitruvian theories has systematized every thing, and laid down laws for collocating and proportioning all the matter it furnishes for architectural composition and decoration. It teaches that columns are modelled from the human figure; that the Tuscan column is like a sturdy labourer—a rustic; the Doric is somewhat trimmer, though equally masculine—a gentleman, perhaps; the Ionic is a sedate matron; the Corinthian a lascivious courtesan; and the Composite an amalgam of the two last! In a composition which admits any two or more of them, the rustic must take the lowest place; on his head stands the stately Doric, who in his turn bears the comely matron, on whose head is placed the wanton, and the wanton again is made to support the lady of doubtful character! But as we in this place are neither apologists for nor impugners of any particular doctrines, we proceed at once to point out the general features of the Italian style; premising only, that, according to the practice of the school, every thing is confined to an exclusive use and appropriation; such columns may be fluted, and such must not; such a moulding may be used here, but not there; and so on. The proportions and arrangements of an order, of any part of one, or of any thing that may come within an architectural composition, are fixed and unchangeable, whatever may be the purpose or situation for which it is required; whether, for instance, an order be attached or insulate, the column must have exactly the same number of modules and minutes in height. It is true that the masters of the school are not agreed among themselves as to those things in which they are not bound by Vitruvius; but every one not the less contends for the principle, each, of course, prescribing his own doctrine as orthodox on the unsettled points.

Mouldings are considered as constituent parts of an order, and are limited to eight in number, strangely enough including the fillet. They are the cyma-recta, cyma-reversa, commonly called the ogive or ogee, the ovalo, the torus, the astragal or bead, the cavetto, the scotia, and the fillet. They are gathered from the Roman remains, but reduced to regular lines or curves, which may be drawn with a rule or struck with a pair of compasses. Arranged according to certain proportions, with flat surfaces, modillions, and dentils, a profile is formed; no two conjoined mouldings may be enriched, but their ornaments, as well as the modillions and dentils, must be disposed so as to fall regularly under one another, and, when columns occur, above the middle of them.

An order is said to be composed of two principal parts, the column and the entablature; these are divided into base, shaft, and capital, in the one, and architrave, frieze, and cornice in the other, and are variously subdivided in the different orders. The Tuscan column must be made seven diameters in height, the Doric eight, the Ionic nine, and the Corinthian and Composite ten. The height of the entablature, according to some authorities, should be one fourth the height of the column, and, according to others, two of its diameters. The parts of the entablature of all but the Doric may be divided into ten equal parts, four of which are given to the cornice, three to the frieze, and three to the architrave; and in the Doric, the entablature being divided into eight parts, three must be given to the cornice, three to the frieze, and the remaining two to the architrave. For the minor divisions a diameter of the column is made into a scale of sixty minutes, by which they are arranged; but this is obviously irrelevant if the whole height of the entablature is determined by

Pl. LXVI.

Italian Architecture.

the height of the column, and not by its diameter; in this case, therefore, they must be proportioned from the general divisions already ascertained. Columns must be diminished, according to Vitruvius, more or less as their altitude is greater or less; those of fifteen feet high, or thereabout, being made one sixth less at their superior than at their inferior diameter, and that proportion is lessened gradually, so that columns fifty feet high shall be diminished one eighth only. On this subject, however, many of his disciples controvert the authority of their master; and some of them have fixed the diminution at one sixth of a diameter for columns of all sizes in all the orders. The entasis of columns is disputed also, some authorities making it consist in preserving the cylinder perfect one quarter or one third the height of the shaft from below, and thence diminishing in a right line to the top; while others, following Vitruvius, make the column increase in bulk in a curved line from the base to three sevenths of its height, and then diminish in the same manner for the remaining four sevenths, thus making the greatest diameter near the middle.

It being difficult to determine among the masters of the Italo-Vitruvian school whose designs of the various orders are to be preferred, we have selected those of Palladio, certainly not for any superior merit they possess, but because he is more generally esteemed than any other, and because he the most strictly adhered, as far as he could understand them, to the precepts of Vitruvius. It should be remarked, however, that although Palladio has fluted all but the shaft of the Tuscan column, he very seldom fluted columns in his own practice; and indeed it may be called the custom of the Italian school not to flute, how much soever their doctrine may be to the contrary; for fluted columns in Italian architecture are exceptions to the general practice. Swelled or pillowed friezes are not peculiar to Palladio; they are more or less common to the works of most of the masters of the same school. Prostyles being almost unknown in Italian architecture, antæ are not often required; but when they are, the meanest succedaneum imagin-
Pl. LXX. Fig. 3. able is recurred to. Of this, Palladio's Villa Capra, near Vicenza, and Lord Burlington's Palladian Villa at Chiswick, afford striking examples. Pilasters, however, are very common, so common, indeed, that they may be called pro-columns, as they are often used as an apology for applying an entablature. They are described as differing from columns in their plan only, the latter being round, and the former square; for they are composed with bases and capitals, they are made to support entablatures according to the order to which they belong, and are fluted and diminished with or without entasis, just as columns of the same style would be. When they are fluted, the flutes are limited to seven in number on the face, which, it is said, makes them nearly correspond with the flutes of columns; and their projection must be one eighth of their diameter or width when the returns are not fluted; but if they are, a fillet must come against the wall. Pedestals are not considered by the Italo-Vitruvian school as belonging to the orders, but they may be employed with them all, and have bases and surbases or cornices to correspond with the order with which they may be associated. The dado of a pedestal must be a square whose side shall be equal to that of the plinth of the column or pilaster which rests on it, or a parallelogram a sixth or even a fourth of a diameter taller. The intercolumniations of columns are called pycnostyle, systyle, eustyle, diastyle, and araeostyle, and are strictly adhered to in Italian architecture when columns are insulated, and that is not very often; when they are attached, the interspaces are not limited, except when a peculiar arrangement called araeosystyle is adopted. This consists of two systyle intercolumniations, the column that should stand in the mid-distance between two others being placed within half a diameter of one of them, making in fact coupled columns or pilasters. It is applied to insulated columns as well as to those which are attached. Following Vitruvius, the Italian school makes the central intercolumniation of a portico wider than any of the others. Arched openings, in arcades or otherwise, are Plate generally about twice their width in height; if, however, LXVII. they are arranged with a columnar ordinance, having columns against the piers, they are made to partake of the order to which the columns belong, being lower in proportion to their width with the Tuscan than with the Doric, and so on; and the piers are allowed to vary in the same manner, from two fifths to one half of the opening. With Fig. 11 & columnar arrangements, moulded imposts and archivolts 12. are used; the former being made rather more than a semidiameter of the engaged columns in height, and the latter exactly that proportion. Variously moulded key-stones are used, too, projecting so that they give an appearance of support to the superimposed entablature. Smaller columns Fig. 12. with their entablature are sometimes made to do the duty of imposts, and sometimes single columns are similarly applied; at others, columns in couples are allowed to stand for Fig. 10. piers to carry arches. In plain arcades the masonry is gene- Fig. 13. rally rusticated, without any other projection than a plain blocking course for an impost, and a blocking course or cornice crowning the ordinance. Niches and other recesses are at times introduced in the plain piers, which are in that case considerably wider than usual, or in the spandrels over wide piers. Very considerable variety is allowed in these combinations, which will be best understood by reference to the examples. Doors and windows, whether arched or square, follow nearly the same proportions, being made, in rustic stories, generally rather less than twice their width in height, and in others either exactly of that proportion, or an eighth or a tenth more. If they have columned or pilastered frontispieces, these are sometimes pedimented; and, except in rustic stories, whether with or without columns, a plain or moulded lining called an architrave is applied to the head and sides of a door or window. This architrave is made from one sixth to one eighth the width of the opening it bounds, and it rests on a blocking course or other sill, as the case may be. In the absence of columns or pilasters in the frontispiece, their place is fre- Fig. 2 & quently supplied by consols or trusses of various form and and Plat arrangement, backed out by a narrow pilaster, which may LXX. be considered as the return of the frieze of the entablature, Fig. 2. and supporting the cornice. It is not uncommon for the architrave lining to project knees at the upper angles, and this is sometimes done even with consols and their pilasters. With columned frontispieces to gateways, doors, and windows, arose the custom, so frequent in Italian architecture, of rusticating columns, by making them alternately square and cylindrical, according to the heights of the courses of rustic masonry to which they are generally attached, and with which they are less offensive than in other collocations. The practice of the *Cinquecento* school of piling columns on columns, with their accessories, is warranted by the doctrine of its master; but his precepts not being practicable, recourse has been had to the inferior works of the Romans, which present examples of Plate it. The difficulty of preserving any thing like a rational LXIV. arrangement is acknowledged on all hands to be great, if Fig. 1. not insurmountable; for if the first or lowest order be at an intercolumniation fitting its proportions, the second or next above it, though diminished ever so little, is already deranged, for it has the same distance from column to column that the inferior order has, whilst the columns themselves are smaller in diameter, and their entablature

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consequently shallower. This derangement must of course increase with every succeeding ordinance, rendering it indeed impossible to make such a composition consistent. The most approved practice in arranging order above order appears to be, that the upper column shall take for its diameter the superior diameter of the one below it; that when the columns are detached their axes shall be in the same perpendicular line; but when attached or engaged, the plinth of the pedestal of the upper shall impend the top of the shaft of the lower column. The most rational mode, however, for diminishing, if reason can be applied to such compositions, is to carry the diminution through, the outlines of the columns of the lowest order being drawn up in the same direction, and so the columns of every story would take up their place and be diminished in regular gradation. When columns are attached, or pilasters used, in Italian architecture, the almost invariable custom is to break the entablature over every column or pilaster, or over every two when they are in couples. Because of the great length of the intercolumniation, it would appear to have been done at first; but it has frequently been done by some of the most esteemed practitioners of the school, even without that excuse, so that it may be held as approved by them. A basement is either a low stereobate or a lofty story, as it may be intended to support a single ordinance the whole height of the main body of the structure, or indeed the lowest of two or more orders; or as it may occupy the ground story of a building, and support an ordinance, or the appearance of one, above. In either case, much is necessarily left to the discretion of the architect; but in the latter the height of the order it is to support is the generally prescribed height of the basement. A basement may be rusticated or plain; if it be low, and is not arranged like a continued pedestal, it must have neither cornice nor blocking course; but if lofty, a deep, bold, blocking course is indispensable. An attic may vary in height from one quarter to one third the height of the order it surmounts; attics are arranged with a base, dado, and coping cornice, like pedestals, and generally have pilasters broken over the columns below. The rule for the form, composition, and application of pediments in Italian architecture, if it may be gathered from the practice of the school, appears to be to set good taste at defiance in them all. We find pediments of every shape, composed of cornices, busts, scrolls, festoons, and what not, and applied in every situation, and even one within another, to the number of three or four, and each of these of different form and various composition. The proportion laid down for the height of a pediment is from one fourth to one fifth the length of its base, or the cornice on which it is to rest. Balustrades are used in various situations, but their most common application is in attics or as parapets, on the summits of buildings, before windows, in otherwise close continued stereobates, to flank flights of steps, to front terraces, or flank bridges. Their shapes and proportions are even more diversified than their application: that of most frequent use is shaped like an Italian Doric column, compressed to a dwarfish stature, and consequently swollen in the shaft to an inordinate bulk in the lower part, and having its capital, to the hypotrachelium, reversed to form a base to receive its grotesque form. The base and coping cornice of a balustrade are those of an ordinary attic, or of a pedestal whose dado may be pierced into balusters. The general external proportions of an edifice, when they are not determined by single columnar ordinances, appear to be unsettled. The grand front of the Farnese Palace in Rome is in two squares, its length being twice its height; the length of each front of Vignola's celebrated pentagonal palace of Caprarola is twice and a quarter its height above the bastions. In Palladio's works we find the proportions of fronts to vary so considerably, as to make it evident that he did not consider himself bound by any rule on that point. In some cases we find the length to be once and one sixth the height, in others once and a fourth, once and a half, twice, twice and a sixth, and even three and a sixth; and elevations by other masters of the school are found to vary to the same extent. The proportions of rooms, again, range from one to two cubes inclusive, though it is preferred that the height should be a sixth, or even a fifth less than a side when the plan is a square; but the sesquialteral form, with the height equal to the breadth, and the length one half more, is considered the most perfect proportion for a room. There is considerable variety and beauty in the foliate and other enrichments of an architectural character in many structures in Italy, but very little ornament enters into the columnar composition of Italian architecture. Friezes, instead of being sculptured, are swollen; the shafts of columns, it has been already remarked, are very seldom fluted, and their capitals are generally poor in the extreme; mouldings are indeed sometimes carved, but not often; rustic masonry, ill-formed festoons, and gouty balustrades, for the most part supply the place of chaste and classic ornaments. This refers more particularly to the more *classic* works of the school; in many of the earlier *Trecento* structures of Italy, and on monuments of various kinds, we find what may be called a graceful profusion of ornament, of the most tasteful and elegant kind; few carved mouldings, however, and very few well-profiled cornices, are to be met with in Italian compositions of any kind. In many of the later architectural works of that country we find again a profusion of ornament of the most tasteless and inelegant description, chiefly in the gross and vulgar style, which is distinguished as that of Louis XIV. of France.

Pl. LXX. Fig. 1

Pl. LIX.

Pl. LXX. Fig. 2

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Of Pointed Architecture.

There are so many varieties of this beautiful style, and the variations are at the same time so considerable and so minute, that it is impossible to describe it generally. Every country in which it was practised had some peculiarities in its composition, and, to develope it perfectly, all of them should be pointed out. This, however, would far exceed our limits; and as the specimens of our own are not excelled, if indeed they are equalled, by those of any other country, a consideration of the style as exhibited by them will afford us a better opportunity of developing it than could be obtained by making our observations more general.

Various classifications of Pointed architecture have been made, and in almost all of them the arch is considered the index, as the column is in columnar architecture; for, like that, it is more expressive of variety than any other feature in the composition to which each belongs. These, too, form the grand distinctions between the Greek and its derivative styles, and the Pointed; but, independently of the column in the one and the arch in the other, the two species of architecture may be said each to have certain governing principles, which sufficiently distinguish and make it impossible to mould them together in one composition, and almost to apply any of the leading forms of the one to the other. They may be thus generally laid down. In Greek and Roman architecture the general running lines are horizontal, as in entablatures and single cornices. In Pointed, the general running lines are vertical. In the former, arches are not necessary to a composition; in the latter, arches are a really fundamental principle. In Greek and Roman, again, columns require an entablature; in the Pointed style no such thing as an entablature composed of parts is appli-

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cable to the pillars, columns, or shafts. (*Vide* Rickman's *Attempt*, &c. p. 110.)

These, however, only determine the generic differences which exist; the varieties in the former style we have found to be marked by such and such distinctive features in the columns and their accessories, which allowed them to be divided into orders. In the latter the varieties arise chronologically, and, consisting for the most part in the forms and arrangements of details, are not incoherent; nor are certain proportions either fixed or determinable, and consequently they cannot be rendered into orders.

It has been customary, in treating of Pointed architecture, to class with it the Saxon and Norman Gothic styles. This is at least unnecessary, as they have no direct relation to it, except that of immediate precedence in point of time, and that the one was the stock on which the other was grafted. The peculiarities of Pointed architecture are indeed totally independent of those of its predecessor the Gothic; nevertheless we should hardly be excused for passing over the latter in total silence.

According to the best authorities, there are very few specimens of architecture now in existence in this country which can properly be called Saxon, that is, of a date anterior to the Conquest, and not of Roman origin; and those few are of the rudest and most inferior description. Saxon, therefore, as far as the architecture of this country is concerned, is an improper term. All the ancient structures which are distinguished by the semicircular arch may be called Anglo or Anglo-Norman Gothic. It consists principally of massive columnar piers supporting semicircular arches, similarly arched doors and windows, and arches on small columns in relief, against a dead wall, to ornament it. The pier when round has a rude foliate or rounded capital, and generally a moulded base, and is variously ornamented on the surface, being altogether a rude resemblance of the columns of Roman architecture: it is at times polygonal, and sometimes piers consist of clusters of small round shafts. In doors and windows thin columns with rude capitals and bases frequently receive the mouldings of the arch; and, when the opening is divided, they are placed like mullions, to support the inner arches. There are examples of this style which are quite plain in every particular; but it is generally enriched by deep congeries of mouldings on the arches, and, when there are no columns, running down the jambs of doors. These are again frequently carved, and mostly with the zigzag or chevron ornament: grotesque masks, and rude representations of animals, foliage, and flowers, form also common enrichments in Anglo-Gothic architecture.

Pl. LXXI. Fig. 1, 2, 3, 4, 5, 6, 7, 8, & 9.

This style prevailed down to the reign of Henry II. of England, when the pointed arch made its appearance. A degree of impressive grandeur pervades its productions, notwithstanding their clumsiness, arising from the great simplicity of manner and massiveness of proportion by which it is distinguished. The best existing specimens in London are the vestibule of the Inner Temple church, which, moreover, exemplifies the transition; many parts of the church of St Bartholomew in Smithfield, and the chapel of the Tower of London. Exemplifications of the style are also to be found in the interiors of Norwich, Chichester, Gloucester, Canterbury, Worcester, Rochester, Winchester, Durham, Peterborough, Oxford, and Hereford Cathedrals. According to Mr Rickman, the naves of Peterborough and Rochester are the most unmixed specimens. Parts, which are easily distinguished, of the exteriors of many of the same edifices, portions of Lincoln, and the towers of Exeter Cathedrals, Bigod's Tower at Norwich, and the White Tower in the Tower of London, afford characteristic external examples of the Anglo-Gothic style. The most striking castellated remains are those of Rochester in Kent, Hedingham in Essex, Conisbrough in Yorkshire, and Guildford in Surrey. Many minor edifices, principally ecclesiastical, exist in almost every county in Great Britain. Mr Rickman remarks two specimens of this style as peculiarly deserving of attention; the one in the vestibule or entrance of the chapter-house at Bristol, and the other in the staircase leading to the registry of Canterbury Cathedral; the former for its simplicity and beauty of composition, and the latter for its singularity, and as exhibiting a very fine specimen of enrichment. The roofs, or ceilings rather, of the Anglo-Gothic edifices, were mostly of wood; but there are various examples of stone-groined ceilings to be found in crypts, which appertain to this style. Spires were unknown: there are, however, turrets crowned with large pinnacles of a date anterior to the introduction of the pointed arch, as in Rochester Cathedral, and the Church of St Peter in the East at Oxford. Towers were not uncommon; they are square massive structures, rising to no great height above the roof of the buildings to which they are attached. It may be remarked in addition, that many of our ancient structures retain the circular-headed or Anglo-Gothic door, when all the rest has been removed, and replaced by work of a later date.

Architects and antiquaries have generally agreed in dividing Pointed architecture into three styles of three succeeding periods. The first commences with the establishment of the pointed arch, and the formation of the style or manner which accompanies it, in the latter part of the twelfth century, the time of Henry II. of England; the second arose in the beginning of the fourteenth century, in the latter part of the reign of Edward I., and was itself superseded before that century closed, about the time of Richard the II., by the third style, which is the latest, for with it, on the introduction of the *Cinquecento*, Pointed architecture ceased to exist. A difficulty arises in appropriately naming these three styles, for on that point there is no degree of accordance among those who are best qualified to be considered as authorities. Mr Rickman calls the first the "Early English" style, the second the "Decorated English," and the third the "Perpendicular English;" to all of which terms Mr Britton objects, and, without giving appellations, except to the first, which he calls the "Lancet Order of Pointed Architecture," suggests that the second might be named with propriety the "Triangular Arched," and the third the "Obtuse Arched." Objecting strongly to the term "Order," used by Mr Britton, we think with him that the first might be appropriately called the "Lancet Arch" style; but his other distinctions are certainly not more defensible than Mr Rickman's. In the absence, therefore, of unobjectionable distinctive terms, as the varieties arise chronologically, we will speak of them as Periods.

Of the First Period of Pointed Architecture.

Mr Rickman describes this style as being distinguished by pointed arches, and long narrow windows without mullions, and a peculiar ornament, which, from its resemblance to the teeth of a shark, he calls the toothed ornament. There is very considerable variety in the forms and proportions of its different examples, as they retain the massive character of the Anglo-Gothic, or tend to the more florid style of the next period. In the former the sharp lancet arch is found at times, in a series of its narrow windows, with rude piers between them, occupying the place of the precedent large circular-headed opening; and in other places springing from the round columnar piers of the former period. In its more advanced works we find the same long narrow window systematically arranged, singly or triply, with light clustered columns, against the

Plate LXXI Fig. 1.

Pl. LX Fig. 12

Fig. 11

Plate LXXI Fig. 1.

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piers which divide them, receiving the deep congeries of mouldings which forms the archivolt. Its columned pier, too, consists of clustered shafts, generally on a round core, and always forming cylindrical masses, girded at different heights with slight rings or belts of mouldings. Their capitals consist for the most part of congeries of mouldings following the form of the shafts, though rich and flowering capitals are not uncommon. Moulded bases, too, are generally used, not dissimilar in form to what is called the attic base of Italian architecture.

Pl. LXXI. Fig. 1. Plate LXXII. Fig. 1.

The lancet arch is described from two centres about an acute-angled isosceles triangle in the line of its base, with a radius equal to twice and one third (in some cases more, and in some less) the length of that base, or of the span the arch is to embrace. This, though the ordinary, is not, however, the universal form of the arch in the first period; but the absence of mullions, and in general of tracery, may almost be considered a criterion: yet foliations or featherings are not uncommon, especially in doors, and as enrichments to flat surfaces, though every thing of the kind certainly indicates an approach to the style of the succeeding period. Ribs on the angles formed by the intersections of arches in groined ceilings, not in ramified tracery, but with bosses at their apices alone, appertain to works of the first period. These ribs sometimes spring from corbels, and sometimes from the heads of slight shafts, which may run uninterruptedly from the floor to the springing of the arched ceiling, against the walls or against the columnar piers; and a small cornice or tablet continuing round them, runs along horizontally to separate the vertical from the vaulted surface. Buttresses in general, of various forms, sometimes in diminishing stages and sometimes upright, with acutely gabled heads without crockets, but having finials—and flying buttresses in particular—belong to this style. The tablets or cornices, mouldings, ornaments, and the variety and arrangement of niches, must be gathered from examples. The parapet or battlement is straight and uninterrupted, and is either plain or ornamented with series of arches or panels with foliations. Turrets are in some cases square, in others octagonal; but the pinnacles which surmount them are almost always of the latter form, and plain or crocketed, as the work may be more or less ornate. Towers, in the style of this period, were generally made to receive that beautiful characteristic of Pointed architecture, the spire. This, in the best examples, is octagonal in its plan, and of pyramidal elevation, running to a point, or nearly so, under an angle of about 12°, the angle at the base being consequently 84°. In some cases the spire is richly crocketed like the pinnacles; but whether plain or crocketed, it is surmounted by a bold finial.

Plate LXXI. Fig. 4.

The most perfect structure in this style throughout is Salisbury Cathedral, which, unlike any other Pointed cathedral in England, except perhaps that of Bath, was begun and finished in the same manner; and so excellent an example is it, that it has been proposed to call the style of the period the Salisbury style. Not inferior in merit, and hardly less perfect a model of the same, is Beverley Minster. That which is of later date in it is easily distinguishable; and being confined to particular parts, it hardly interferes with the unity of the composition. The transepts of York Minster are also of the first period, and so is a great part of Westminster Abbey. The fronts of Ely, Lincoln, and Peterborough Cathedrals exhibit good specimens of it. Indeed there is hardly one of all our Pointed cathedrals which does not partake of this style in a greater or less degree. It will be most generally found interwoven with and superimposing the Anglo-Gothic where that exists, and inferior to, when in connection with, works of a later period. Many of the monastic structures with which this country abounds present very beautiful specimens of this style also. Among other excellent examples of it may be particularized the chapter-houses of Lincoln and Lichfield. Those beautiful monuments which the affection of Edward I. induced him to raise to the memory of his wife, called the Crosses of Queen Eleanor, are in the style of the first period, though they verge on that of the second, and indeed mark the transition which took place in the latter part of that king's reign.

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Of the Second Period of Pointed Architecture.

The style of this period, which is thought by many to be the classic age of Pointed Architecture, is described by Mr Rickman as being distinguished "by its large windows, which have pointed arches divided by mullions, and the tracery in flowing lines forming circles, arches, and other figures, not running perpendicularly; its ornaments numerous and very delicately carved." Mr Britton says that "during this period the Pointed style received its greatest improvements;" and that, limiting it to the time of Edward III., "the form of the arch then principally in vogue admitted of an equilateral triangle being precisely inscribed between the crowning point of the arch and its points of springing at the imposts." The mullions of this style clearly result from the slender shafts which were used in that of the first period against the piers dividing a number of windows. The piers being removed, it became necessary that an arch should be turned from side to side, leaving a space to be filled up in the head above the smaller arches. This was done by repeating and continuing their contours, and connecting them by gracefully flowing lines and foliations. It is indeed but an extension of the former; for in some of the early examples the mullions are thin columnar shafts having capitals and bases, and the head of the arch is generally filled up with regular figures, such as foliated circles, leaving spandrels or triangular circular-sided spaces in various parts. It is in the more advanced works of this period that the tracery becomes what may be truly called flowing. The mullion is angular and moulded, and the mouldings run all through the composition; the jamb or architrave mouldings also run through, and for the most part without the intervention of any horizontal mouldings at the impost or springing of the arch. Besides the ordinary covering cornice or drip-stone following the form of the arch, we find a moulded cornice, generally arranged pediment-wise, embracing a window or door, having crockets and finials, and resting on corbels, which are almost always masks. This may be called an attached canopy. The columnar piers of this period are nearly square in plan, and are placed diagonally. They are sometimes composed of clustered shafts, and sometimes of shafts separated by deep hollows. Their capitals are either moulded simply in rather a deep congeries, or with woven foliage under a moulded abacus. Their bases are a diminishing series of bold mouldings, supported generally by a vertical-faced octagonal plinth. The shafts which support the ribs of the roof or ceiling tracery, in the finest examples of this style, spring from rich and bold corbels in the angles of the arches, or the spandrels, immediately above the piers. The groining ribs do not adhere to the angles of the groins merely, but are set more profusely to form tracery; and rich bosses are put at every intersection. Buttresses of the second period are exceedingly various: on angles they are mostly set diagonally. They either diminish gradually in heights or stories, and finish under the cornice, or they run through and are surmounted by pinnacles. In some cases the sets-off in diminishing are made simply with an inclined shelf; in others every set-off is formed with a pediment properly

Plate LXXII. Fig. 2 & 3.

Fig. 4 & 5, and Plate LXXIV. Fig. 1.

Plate LXXIII. Fig. 2.

Plate LXXIV. Fig. 1.

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enriched, and the face of the buttress is generally ornamented with blank tracery in panels or niches. Flying buttresses in this style are also more ornate than those of the preceding; indeed in this they became ornaments, whereas in the former they appear to have been kept out of sight as much as possible. Parapets are either pierced or embattled, and a similar variety is maintained in pediments. Pinnacles are generally square, but they stand diagonally with regard to the turret or buttress on which they are placed, their angles resting on the apices of the pediments which surmount the faces of the substructure. These pinnacles are richly ornamented with crockets and finials. Spires are less common in the more extensive works of this period than in the precedent; but in those of minor importance they are frequent, differing little, however, from the same object in works of the first period, except in being more highly enriched. Towers are richly pinnacled; but the pinnacles rest for the most part on small turrets rising from the angles of the tower itself, and seldom from projecting turrets or from the heads of buttresses, which latter are generally found to die away below the cornice. The details and enrichments of this style are too curious and complicated for verbal description, but they may be gathered from the examples.

We possess no one complete cathedral of the second period, but almost all our larger Pointed structures present specimens of it in a greater or less degree. Excepting perhaps the upper story or belfries of the towers of York Minster, which are of the third period, its west front is a model for this style, and it presents specimens of almost all its external peculiarities. The nave of the same edifice, and the interior of Exeter Cathedral, are perhaps the finest examples of the second period. The latter edifice, indeed, has the reputation of presenting a greater and more pleasing variety of tracery than any other of the same style. To these may be added the cathedrals of Lincoln and Ely, both of which contain much that is valuable. Next to these cathedrals may be placed Beverley Minster, which is not only a mine of beauty of the first, but it presents many exquisite specimens of this period also. The steeple of St Mary's Church, Oxford, is a fine example in this style of the combination of tower and spire. Many minor works in England, and several in Scotland, are excellent; particularly much of what remains of the High Church, Edinburgh, much of the remains of Elgin Cathedral, and the largest portion of those of Melrose Abbey, which, it would appear, was not excelled, when perfect, by any thing in the kingdom.

Plate LXXIV. Fig. 1.

Of the Third Period of Pointed Architecture.

This is that period of the style commonly known as florid Gothic. The first authority quoted with regard to the styles of the two preceding periods calls it the Perpendicular English, and says that this name clearly designates it; "for the mullions of the windows and the ornamental panellings run in perpendicular lines, and form a complete distinction from the last style." Mr Britton, however, insists that the term *perpendicular*, though perhaps proper enough, if the style could be sufficiently distinguished by the mullions of the windows and the upright forms and continuity of the panelling over entire surfaces, "gives no idea of the increased expansion of the windows, nor of the gorgeous fan-like tracery of the vaultings, nor of the heraldic description of the enrichments which peculiarly distinguished this period; neither does it convey any information of the horizontal lines of the door-ways, nor of the embattled transoms of the windows, nor of the vast pendents that constitute such important features in the third division." Although windows with tracery in them may be determined as belonging to this period, by the perpendicular and parallel lines found in the head or arch, and by the use of transoms to divide the bays into heights, yet the presence of a window of this kind does nothing towards fixing the style of the edifice generally to which it may belong; for in hundreds of cases this sort of window will be found where it is the only specimen of its age or style in the structure. Other points must therefore be attended to.

Point Architecture Plate LXXI Fig. 6.

The simpler arches of this style are, like those of the preceding periods, struck from two centres only; the two sides or halves of the arch are similar segments of a circle whose radius in this case is about three fourths the width of the opening. Others are segments of ellipses, and are of course struck from four centres; but some are eccentric curves, which may be drawn, but cannot be described. Many of both the latter descriptions are extremely flat or depressed, the angle at their apex being very obtuse. The ogee or contrasted arch is also found in works of this period, but this is more common in internal tracery than in external form. The modes of arranging tracery must be gathered from examples, for they possess no degree of regularity to render it possible to describe them generally in words. Mullions are richly moulded, and so are the architraves of both doors and windows; the deep congeries of mouldings forming architraves are not intercepted by horizontal or impost mouldings, but run through from the head down the sides or legs. The angular or pedimented canopy to an arched opening in the style of the second period assumes in this the form of a contrasted arch; it is corbelled and enriched with crockets and finials as in that. Doors, however, in this style are peculiar, because whatever the form of the arched head may be, it is inscribed in a square frame or canopy, the spandrels being variously enriched. Columnar piers of this period are of almost parallelogramic form, thinner in the direction of the arches, and generally plain on the longer sides, but deeply moulded and running to a thin shaft on the outer edges. These mouldings are those which enrich the arch, there being no capital of any kind to intercept them, so that they run, as in windows and doors, all round the opening. To this, however, there are exceptions. The thin shaft which is formed on the outer edge of the pier continues through from floor to ceiling, to receive the groining ribs; and it has a thin congeries of mouldings at either end to form base and capital. The tracery of the ribs of groined ceilings of this period is most profuse, and beyond description intricate. To this also belongs the absurdity called basket groining, in which the arches are made to spring on one of their sides from a pendent mass, which, though rich and gorgeous in appearance, threatens constant ruin. Corner buttresses standing diagonally are not so common in this as in the preceding style: in form, however, they are not dissimilar, excepting that the sets-off are plain moulded slopes for the most part, instead of having pedimented or triangular vertical heads, as in that. Flying buttresses are, like the style generally, very much enriched, and are very commonly used. Parapets are variously arranged; indeed they embrace almost every peculiarity, being either plain, panelled, pierced, or embattled; and each of the latter modes is effected by different means. Pinnacles in this style are generally square, but there are examples of them having a greater number than four sides; in the former and most usual case they are sometimes placed with their sides parallel to those of their pedestals, and sometimes diagonally: they are of course in every case highly enriched with crockets and finials. Spires of this are hardly distinguishable from those of the preceding period; and towers, of which there are innumerable specimens, may be known by the construction of their buttresses, and by the arrangement of the tracery in the heads

Plate LXXI Fig. 1.

Plate LXXI Fig. 1.

Window of tower Plate LXXI Fig. 1.

Fig. 4.

Fig. 1.

Fig.

Pointed Architecture.

of their windows, as the windows of towers are generally contemporaneous with that story, or stage of it at least, to which they belong. Octagonal or otherwise polygonal turrets at the angles of buildings are not uncommon, and they generally finish with an embattled parapet. The pedestals which support the pinnacles on the angles of towers, and at the heads of buttresses, seldom have pedimented faces, as in the preceding period, but finish with a corbelled battlement, and not unfrequently send up minor turrets and pinnacles from its angles.

In the more ornate works of this style the enrichment of flat surfaces is carried to great excess, and it is generally effected by means of panelling. Niches with their canopies, tabernacles, screens, and stalls, exhibit the most exuberant profusion of ornament, for the most part effected in this manner; but we find, besides, a considerable variety of ornaments, foliate and heraldic; of the former the Tudor flower, which is a combination of the roses, is pleasingly predominant.

The only one of the cathedrals entirely of this period is that of Bath; but being generally inferior in merit to many other examples, it need not be cited. Many of the cathedrals, however, have large portions in this style, which can hardly be mistaken if the form of the arches, the arrangement of the tracery, and the mode of enrichment, be attended to. The finest west fronts to any of them are possessed by those of Gloucester, Winchester, and Chester; but that of Beverley Minster is by far the most perfect and most classic specimen in existence, if we except the front of Westminster Hall, which is also of surpassing merit, and is moreover a classic exemplification of most of the peculiarities of the style. Taken as separate edifices, the chapels of St George at Windsor, of Henry VII. at Westminster, and of King's College at Cambridge, are the most complete, as they are entirely and peculiarly of the third period. The central towers of the archiepiscopal fanes of Canterbury and York, the tower of Gloucester Cathedral, that of Magdalene College, Oxford, Boston Tower, and the tower of St Mary Magdalene at Taunton, are singularly excellent examples of the style. To smaller edifices, those of Wrexham and Gresford in Wales, and of St Neot's in Huntingdonshire, are particularly beautiful. Of steeples, that is, towers having spires superimposed, there are many fine specimens; but the most perfect, perhaps, in composition are those of Bloxham in Oxfordshire, and of Louth in Lincolnshire: the former is most admirable rather in general than in detail. Many of the monastic ruins throughout the country present excellent specimens of this style also; indeed it is to ecclesiastical structures we must look for architectural display in Pointed architecture, as in that of the Egyptians, Greeks, and Romans. We have just specimens enough existing of the architecture of the secular structures of our ancestors to show how inferior it was in merit to that of the ecclesiastical; and if the castellated mansions of the nobility, and the palaces of the sovereigns, cannot vie in excellence with the cloistered cells of the monks, we may be well assured that ordinary domestic architecture was of a still more inferior cast.

Plate LXIV. Fig. 8

Elements of Beauty in Architecture.

Simplicity and harmony are the elements of beauty in architecture; simplicity in the general form and arrangement of a subject, and harmony in the collocation and combination of its various parts. Without these qualities a structure can never possess either dignity or grace, and with them it will certainly possess the attractions of both. The outline, then, most conducive to beauty in architecture, is that which bounds the most simple forms. These are the parallelogramic and pyramidal, in which the lines are straight and uninterrupted throughout their whole length. The ancient monuments of Egypt, of Greece, and of Rome, offer the most complete exemplifications of this. No other than the long, unbroken line which bounds the temples of Egypt could produce an effect so grand; and no other than the simple, square, and pyramidal forms, could be productive of so much dignity as they possess. In the pyramids and obelisks of the same country the effect of this simplicity is even more obvious. In the temples of Greece, again, the same dignified simplicity is still predominant; for although in them the parallelogram and pyramid are combined, they are not confused; their mass consisting of a parallelopipedon whose ends are surmounted by vertically faced pyramids, connected by an unbroken line of ridge running parallel to the horizontal boundaries of the sides. Those of the Roman monuments which are deficient in simplicity are also deficient in beauty. Such are the triumphal arches, whose general form is broken by columns and arches which subject themselves to no commanding outline, but are all at the same time prominent features of and excrescences from the general composition. In the temples which are on the Greek model it is not so; nor is it so in the long series of arches in the Roman aqueducts, which are crowned and connected by commanding lines, unimpeded by projections or protuberances of any kind. The crucial form of the Pointed cathedral may be thought to detract somewhat from its simplicity, and so much from its beauty; but it is an aggregation of simple forms, perfectly coherent with the tendency of the leading lines in the style, which, we have seen, is vertical; and the lines are therefore not broken by the projected masses of the transepts, as they would be in the Egyptian and other styles, the tendency of whose commanding lines is horizontal. Otherwise the Pointed cathedral is a modification merely of the form of a Greek temple, with other parallelogramic forms added to it, as towers, or pyramidal, as spires. The same principle will be found to pervade the best works of the Italian school, more or less modified according to its application.

Beauty in Architecture.

Pl. LVI.

Pl. LIV.

Pl. LXIV. Fig. 10 & 11.

Next to the straight line is the circular; but the greater complexity of this latter, and the variety of which it is capable, render it more subtile, and for the most part less competent to produce grand and impressive effects, except under peculiar circumstances of situation and combination. A cupola such as the cupolas of St Peter's at Rome and St Paul's in London, if placed on its base on the ground, or even on a low structure, like a large beehive, would be not merely ineffective, but absolutely ugly; and if, in the situations they occupy, the cupolas referred to were without the diminishing pinnacles above them, to bring their general outlines within that of the pyramid, it is a question whether they would possess the attractive beauty they now do. If St Paul's be looked at in the gray twilight of morning or evening, or when a mist renders its form indistinct, the impression conveyed by the mass is that of a lofty pyramid or cone, rising out of the substruction which the cathedral forms, and running off to a point in the sky. The superstructure of St Peter's is, as we have seen, more depressed, and less perfectly formed in this particular; yet nevertheless it may be submitted to the same test, and the same or nearly the same result will follow. Furthermore, let a hemisphere or an oblate hemispheroid be supposed in the place of the prolate hemispheroid, as at present, and this reasoning will be rendered more clear; for neither of those forms, even with the accessories these possess, would be as beautiful; and without them they would be ungainly deformities, as is proved by that example on the new palace in London, on the site of Buckingham House.

Pl. LXIX.

Beauty in Architecture.

The cupola of the London University exemplifies this point also; for though its profile is elegant, and its accessories are generally good, the composition does not resolve itself into a simple form, and the result is far from being beautiful.

When the circular form is employed cylindrically, the utmost simplicity is required to be preserved in its horizontal, as well as in its vertical lines, or the result will be totally devoid of all architectural beauty. In proof of this, let the broken and dentilled columnar ordinance which surrounds the tholobate of St Peter's be compared with the noble, unbroken peristyle in the corresponding part of St Paul's. In the former the cylindrical mass is studded with a series of minute excrescences of coupled columns; and in the latter it forms a grand, beautiful, and effective compartment of the composition.

The preceding remarks do not of course apply to the interior of a structure in the same manner; for although as high a degree of simplicity is required internally as externally, similar combinations are not necessary, nor are they indeed always available. A spacious concave, of whatever form its profile may be, so that its plan be a perfect circle, is one of the grandest works of architecture, and at the same time one of the most simple, whether it occupy a compartment of the structure to which it belongs, as in St Peter's and St Paul's, or cover the complete edifice to which it appertains, as in the Pantheon at Rome. In such situations it is indeed almost impossible to destroy its inherent simplicity; and being unconnected with external circumstances, it requires no coherence with any thing else, being as independent of its substructure as of its external contour for effect. Irregular and intricate forms, however, in works of architecture, whether internally or externally, will be found unpleasing. Few can admire the external effect of the Pantheon, or of the structure in London called the Colosseum, which has been subjected to the same arrangement, though certain features in both may be indisputably good. To these may be added the church in Langham Place, London, and indeed many others; but that is an egregious example in point. The complication of straight and circular in their composition, and the consequent irregular forms and undefined outlines, totally destroy both simplicity and harmony. The comparison of an Egyptian obelisk with a monumental column of the same relative size will afford the strongest proof of the superiority the more simple form possesses over the more complicate. None, however, but those who have visited Rome, in which city alone the comparison can properly be made, can duly appreciate this evidence; but London furnishes a contrast almost as much to the purpose, in the monument on Fish Street Hill, and the lofty shot tower by the south-west angle of Waterloo Bridge. They are both of cylindrical form; but the one is crowned by a square abacus, and the other by a bold cornice, which follows its own outline. The greater simplicity and consequent beauty of the latter is such as to strike the most unobservant.

Pl. LXIV. Fig. 4.

Fig. 1 & 2.

Not only in general form and outline is simplicity necessary to beauty in architecture, but in all its details, and even in its enrichments, also. In exemplification of this, a Greek entablature may be compared with one in the Roman style, in which every thing is sacrificed to profuse ornament; and the style of ornament in the latter may again with equal advantage be compared with that of the age of Louis XIV. of France. In the arrangement of the parts of a composition, as well as in the composition itself, simplicity is essentially necessary to the beauty of the whole; every style will afford exemplifications of this also, in the comparison of the more simple with the more complicate specimens of the same. Compare the few simple and well-defined parts of a Grecian Ionic entablature with a Roman or Italian example of that order: in the latter will be found a complexity and straining at effect not at all consistent with beauty and dignity, determining the comparison much in favour of the first; and so in many other cases which might be cited. That the more simple arrangement of columns at equal distances is superior to that in which they are coupled or placed only alternately equidistant, is clear from the fact that the latter mode was first proposed, and is only used to obviate difficulties, and not from choice, except in the works of the merest pretenders.

Pl. LIX. Fig. 5.

Beauty in Architecture.

Pl. LXI. Ex. 3. Pl. LXI. Fig. 4.

Harmony, concord, or fitness—of proportion, of form, of one part of a composition to another, and in the collocation of the various enrichments which architecture requires,—is as necessary to its beauty as simplicity. We do not speak of the agreement which should exist between the manner or character of a structure and its application, for that is purely conventional, and totally independent of any architectural consideration. The merit or demerit of a composition is not at all affected by the use to which the edifice is applied; neither would its front be more tolerable, nor its cupola less beautiful, if St Peter's in Rome were, by the course of events, to become a democratic forum instead of a papal basilica; nor is the monument of London a more or less elegant object, whether it be understood to record a triumph or a defeat—the burning of the city, or its re-edification. Harmony in architecture is that agreement which exists between its various parts, as in the relation of a column to its entablature and stylobate, in the accordance of a cornice with the elevation it crowns, and in the coherence of one part of a composition with another. It is that which exists in the common tendency of the leading lines of a structure; and it is that which blends the straight and circular in enrichment or decoration, as in the capital of an Ionic column whose square and horizontal form is harmoniously adapted to the vertical lines and cylindrical form of the shaft, by the intervention of the volutes. An inharmonious combination arises out of the collocation of the same voluted capital with a pilaster or square pier. This quality requires a judicious arrangement of ornament. That a certain degree of enrichment should pervade the whole of a composition, and not be confined to one part of it—for instance a Corinthian ordinance, in which the columns are unfluted and the entablature is quite plain—is inharmonious; for the capitals being masses of rich foliage, are spots, having nothing to connect them with the rest. A degree of harmony must exist, too, between the solids and vacuities of an edifice. An Italian portico, with its thin and straggling columns, is an inharmonious object, for it conveys an idea of infirmity and poverty, which is not the case with one proportioned like the best Greek and Roman examples. In the front of a house, windows and the piers between them being too wide or too narrow will affect its character in this respect. The comparative size of various portions of the same composition, though they be in themselves simple and harmonious, may be such that they shall not be so in combination. The portico of the London University is of almost unequalled magnificence and beauty, and the cupola behind and above it is of elegant form, though deficient in another particular, as we have already stated; yet they do not harmonize—the one is much too large for the other, and their forms are incoherent.

Thus harmony has reference to comparative magnitude, strength, decoration, disposition, and proportion. To acquire a knowledge of all these sufficient to produce a worthy result, a long course of study and careful observation are necessary: but such can only be necessary to the architect; it is enough for the general student to be

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able to appreciate them when present, and to detect their absence.

Principles of Architectural Composition.

These must be different in the widely differing species of architecture, whose tendencies in the one are to horizontal or depressed, and in the other to vertical or upright lines and forms; the former including all those varieties which derive from the Greek and Roman modes of design, or columnar and circular-arched architecture; and the latter embracing those which arise out of the pointed arch, and which we have distinguished by the term Pointed. Except in the elements of architectural beauty, which must be the same in all architectural works, there is no similarity whatever between the principles which govern composition in the two species. Simplicity of form, and harmony between the parts, are as essentially necessary to the one as to the other; but instead of the leading horizontal lines required by the former, the latter is distinguished by the absence of commanding lines having that tendency, and by the presence of strongly marked lateral projections and vertically inclined lines. The rectangular figure formed by the front of a Greek temple, below the pediment, rests on one of its longer sides as a base. In a Pointed composition that order is reversed, and one of the shorter sides becomes the base; and the pediment, instead of being a depressed obtuse-angled triangle, becomes upright and acute-angled; the whole mass, moreover, follows the change thus described, so that the same figure, a parallelopiped, is set for horizontal or vertical composition, as a larger or smaller side is made the base. This being the case, it will be necessary to treat of them separately; for rules which apply to the one are totally inapplicable to the other, and the former, being of most common application, may be taken first. We shall quote the principles which appear to have actuated the Greek and Roman architects in the production of their best works, or rather the principles which those works develope, instead of citing all existing ancient works as authorities; and determine on those principles how to produce similar results in cases of which examples do not appear in ancient practice. In the same manner, we must deduce the principles for general composition in the Pointed style, from those which appear to enter into its best existing works.

Of Horizontal Composition.

Every thing tending to break the continuity of the leading horizontal lines in a composition should be avoided. The advantage of adhering to this, and the disadvantage resulting from the breach of it, are clearly exemplified in the front of the Farnese Palace, and in the flank of St Peter's at Rome. In London, too, the fronts of the Banqueting House at Whitehall, and of Somerset House to the Strand, offer similar exemplifications of the principle; the former having both the entablatures and the stylobate of the upper ordinance broken round every column, which makes the ordinances mere excrescences, and the latter preserving the leading lines continuous and unbroken throughout, to the manifest advantage of the whole composition. This applies equally to columned and arcaded ordinances, and to compositions in which neither is used; and it is as much opposed to the projection of masses to form wings and centres, whether shallow or deep, as to the breaking of an entablature or stylobate round one or two columns. Sufficient variety of light and shadow is attainable without the use of columnar ordinances at all, as the Farnese Palace evinces. But if, however, it be required to give a greater degree of importance to an elevation than can be attained in that manner, it may be produced without either attaching or insulating columns the whole extent, by means of antæ and recessed compartments with columns in them, as on either side of the gates in the north or Lothbury front of the Bank of England, and on the flanks of the churches of St Pancras and St Martin in London; but a mere pilastraded ordinance, or pilasters with an entablature and without columns, is bald, tasteless, and unmeaning, as the front of Crockford's Club-house, in London also, very clearly shows. In speaking of the Italian style, we have shown the injudiciousness of putting order above order, because of the impossibility of maintaining a rational arrangement with regard to diminution and intercolumniation. We made that, too, an objection to the elevation of the Roman Colosseum; but the practice is moreover objectionable, because of the repetition of the similar parallel lines of the entablatures, similarly projected too, which destroy the breadth a composition should possess; and because the upper and crowning cornice, if in proportion to its own ordinance, must be disproportioned to the whole elevation which takes from that member a character of grandeur or meanness, as it may or may not be fitted to its whole height. This is made very evident by the opposed fronts of the United Service and Athenæum Club-houses in London, the former of which is finished by the thin shelf-like cornice of a second order, and the latter by a bold massive crowning cornice in the style of that of the Farnese Palace. In a similar manner, and for the same reason, the practice of raising lofty basements to support columnar ordinances is injudicious; and this detracts much from the merit of the front of Somerset House just referred to, by making the crowning cornice of less importance than it should be. In St Paul's this fault is partially relieved by the somewhat exaggerated size of the cornice of the upper order, and by the insertion of cut blocks, in the manner of upright modillions, under it the whole depth of the frieze. Nothing, again, should be allowed to superimpose a crowning cornice, except what may form a part of itself, as antefixæ; where, however, something is absolutely necessary, as on a bridge, a close simple parapet, as low as it may be conveniently, should be resorted to. On the principle first developed, porticoes should not be projected from the front of a building, unless they occupy the whole extent of it, as in a Greek or Roman temple, and so carry the horizontal lines unbroken to the flanks; or they should be made distinct and independent objects, to which the rest of the composition may be subservient, as in the London University. A portico should moreover be considerably projected, or the surface behind it recessed, that the columns may have a background of shadow, otherwise it will be poor and inefficient. Of this the Greek temples offer a favourable exemplification; and most of our churches, and other modern edifices which have porticoes to them, prove the correctness of the principle in the breach of it. Exceptions more or less favourable certainly exist, whose superior merit is sufficient to indicate them. A pediment should never be used unless it is made to embrace the whole of the end or front to which it is attached. Numberless absurdities have arisen in Italian architecture from the injudicious application of this form; so general, indeed, is it, that the fact of a pediment existing under any circumstance in a work of that style is almost a sufficient reason for avoiding a similar use of it. Nothing is more difficult than to combine straight and circular, or otherwise bending lines, with propriety and good taste, and therefore their collocation, in general composition particularly, should be seldom attempted. It is when they harshly contrast, as in circular pediments, and in mixed compositions of columns or pilasters, with their accessories, and arches and

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their piers, that the combination is bad; but not so in the connection of the arch with its pier, so that the former be semicircular or semielliptical, and not smaller segments, in which cases they fall naturally and gracefully together. The incoherence and inelegance of contrasted straight and circular forms are very evident in the New Exchange at Paris, where two tiers of circular-headed windows are seen within a Corinthian peristyle. Circular prostyles or cyrtoprostyles should be avoided, as their horizontal lines cannot be made to harmonize perfectly with any form to which they may be attached. This however does not apply to peristyles; and both the one and the other are exemplified by the transept porticoes and columned tholobate of St Paul's. The use of coupled columns is so absurd, and they are confessedly so inelegant, that it seems almost unnecessary to proscribe them. Suppose apertures, such as windows, arranged in couples throughout an elevation, with very narrow and very wide piers alternating, and both the absurdity and the inelegance become manifest: now, neither the one nor the other can be either lessened or changed by reversing the case, and putting alternately wide and narrow openings, as in coupled columnar ordinances. Columns may with propriety be put further apart when they are attached than when they are insulated, because the entablature, resting in part on the wall, is neither in fact nor in appearance made infirm by the distension, as it would be if it rested on the columns alone. All the parts of the same edifice which come into view, under any circumstances at the same time, should correspond; but insulated and attached columns of the same ordinance and in the same elevation may, under certain circumstances, without impropriety be arranged with a different intercolumniation.

An arcaded ordinance should be considered as only more massive than, and differently shaped from, a columnar, and may therefore be governed by nearly the same principles. A pier is but a differently shaped and more massive column, and the archivolt but a succedaneum for the architrave; while a bold blocking course, or a commensurate cornice and frieze, as the composition may be more or less ornate, will complete the ordinance. Under this view nothing can be more absurd than to affix columns or pilasters to the piers of an arcade to support an entablature, and certainly nothing can be more inharmonious, from the contrast which arises, as we have just remarked, between the rectangular lines of the latter, and the inscribed circular lines of the arch, as well as the incongruity necessarily attending the interspaces of the columns.

In speaking of Greek and Roman architecture, we have shown why columns should, and why antæ and pilasters should not, be fluted; and have shown also, that a certain degree of richness or plainness of surface should pervade a composition, and not be confined to particular parts of it. It will now be enough to add, that in composing, lights and shadows should not be scattered on a surface as they are on the front of the Banqueting House, by broken ordinances; nor should either be too much narrowed, as the light on the corona of a Roman cornice too frequently is, by the too great projection of the cymatium. It will be found, moreover, that shadows projected horizontally are more in coherence with the horizontal style of composition, than those which fall laterally, or from a vertically projecting object.

Columns, &c.—The proportions of the columnar orders will be best sought in the existing examples of the ancients; and those we give of them afford sufficient variety. What is deficient in one may be made up from another; and what appears superfluous in one example may be omitted, as its omission may appear beneficially to affect another. The Doric may be adopted from the Parthenon or the temple of Theseus, as the best existing models of the order. If an ungraduated stylobate be used, which should be avoided if possible, it should not exceed one diameter in height. The intercolumniation should not exceed one triglyph, as in the Greek temples, though for compositions of a generally less dignified character it may, perhaps, be extended to two. A good modern example of the Doric order, in a work of the latter description, may be seen in the small entrance portico to the University Club-house in London. The Ionic example from the Erechtheum, which we have given, may be used as a model for that order, with the same restriction with regard to the stylobate which is made to the Doric. Additional depth may with advantage be allowed to the bed-mould of the cornice, and it may be effected by the insertion of a dentilled member, which indeed some of the ancient Greek (though not Athenian) examples possess. The intercolumniation should not be less than one diameter and a half, nor should it exceed two diameters. In London this order is admirably applied in the front of an Episcopal chapel on the east side of North Audley Street; and this particular example is very correctly copied on the exterior of the church of St Pancras. The great inferiority of the Roman examples of the Doric and Ionic orders is too evident to require that what it consists in should be pointed out, and they are the models of the Italian. The Greek example of the Corinthian order might perhaps be improved by making the dentil member of the cornice a little shallower, by projecting the corona rather less, and by correcting the form of some of the mouldings of the entablature generally. If the columns be used in a prostyle or other insulate position, they may with advantage be made half a diameter less in height; and the intercolumniation also should be made less than it appears in the original, where the columns are attached. This example has been well executed in the entrance to the Philadelpheion or Exeter Hall, in the Strand; but the pedestals and the attic are blemishes in the composition. Of the Roman examples of this order, that of the temple of Jupiter Stator is certainly the best. Its greatest fault is the too great magnitude of the cornice, of which every member, except the corona, might advantageously be restricted one tenth of its height; that which is dentilled might indeed be reduced one fifth. The projections might also be diminished in the same proportion, removing the greater diminution of one fifth in this particular from the dentilled member to the cymatium, and the ovalo under it, both of which project by far too much. The three fascias of the architrave are too unequally divided. The lowest may be made as wide as the middle one, by deducting their difference from the third or upper one. In the Tivoli example the architrave is too shallow, and so are the dentil band and corona of the cornice; and the cymatium is both too deep and too much projected. The cornice would moreover be improved by denticulating the dentil band, and by enriching the frieze with an ornament less coarse and less massive. If this example be used in a generally ornate composition, some of the mouldings of the entablature should be enriched. The parts of the entablature of the temple of Antoninus and Faustina are well proportioned to each other. The cornice of this example would be improved by giving additional height to the dentil band at the expense of the moulding above it, and by denticulating it also. The cymatium is rather too shallow, and may be widened out of the moulding under it; and both should be restricted in their projection at least one fifth. The capital of this example is poor, and its abacus is too shallow. The shaft requires fluting, and one half the depth of the upper fillet of the base might be added with advantage to the tori and scotia. The cited

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Pl. LV & LVI.

Pl. LI.

Pl. LXI Ex. 3 &

Pl. LX Fig. 3.

Pl. LX Ex. 1.

Ex. 2.

Ex. 3.

Composition. Pl. LXI. Ex. 4. example from the portico of the Pantheon has, like the last mentioned, the parts of its entablature well proportioned to each other. As in the Jupiter Stator example, the architrave should be more equally divided. The mouldings, too, separating the fascias, should be made less; and the superior moulding, at least of the architrave, carved, unless the frieze were enriched, and then it would not be necessary. In the cornice a fifth or sixth should be taken from every member of the bed-mould and added to the corona. In the presence of modillions, however, the dentil band is judiciously kept plain, though the moulding below it would be better if enriched. The capital of this example is as faulty as that of Antoninus and Faustina, and in the same particulars. The shaft also requires fluting, and the base might with advantage be made to spread more. The ordinance of the temple of Pl. LXII. Ex 1. Mars Ultor, though the most masculine, is, from its good proportions, and the bold character of its foliage, one of the most excellent of the Roman Corinthian examples. Most of the entablature being supplied from a not well authenticated source, may not be original; but that is of no consequence, if it be beautiful. The corona, like that member in most Roman entablatures, wants greater depth; and the cymatium perhaps less, and certainly less projection. In this, as in the first-mentioned Roman example, with modillions there are dentils. This is injudicious; the member would be better plain, as in the Pantheon ordinance. The architrave, which is authentic, is exceedingly well proportioned, and the column is fine in all its parts. These examples all vary in their intercolumniation, from rather less than one diameter and a half to a fraction more than two diameters, beyond which proportions, either less or more, it would not be well to go. A stylobate to the order might judiciously be adapted from the Greek; for the stilted effects produced by insulated pedestals, and even by continuous vertical stylobates, are injurious to the general appearance of a columnar composition; and the thin steps in common use detract exceedingly from its beauty under any circumstances.

There are many varieties of the foliate capital which may be used with advantage; one of the least elegant, however, is that which assumes the distinction of being called the Composite order. The example of it from the Ex. arch of Titus is one of the best, if not the best; but it will be seen, on comparison, to be strikingly inferior to the Corinthian examples, or those in which the volutes of the capital are made subservient to the foliage, instead of being distended into huge mis-shapen knobs. The entablature, too, is only an exaggerated Corinthian. If it be wished to use foliate capitals differently composed from the ordinary, it may be well to preserve the character and proportions of the entablature the same, or nearly so. Under any circumstances, however, care should be taken in composing an entablature, that it have sufficient height, and yet not be too heavy; that it be sufficiently divided, and yet not frittered; that the parts have sufficient breadth, and be not so much projected as to bury all that is below them in shadow; and that ornament be properly distributed, and in sufficient quantity, without overloading the composition with it, as in the ordinance of the arch of Titus.

If again it be wished, under any circumstances (though Pl. LX. Fig. 5, & 6 the practice cannot be recommended), to use human figures as columns, there appears to be no reason why the entablature should be executed without a frieze, as it is in the example of the Pandroseum; and if a frieze be inserted, it should be by lessening the other parts, and not by increasing the whole, as that entablature (taking it as a model) is quite deep enough in proportion to the height of the ordinance.

Entasis in columns need not be regarded, unless they exceed eighteen or twenty feet in height; but it adds much to their beauty, and should not be neglected when they are above that magnitude. No rule can be given for its production, but it may be thus described. The shaft, instead of being the frustrum of a regular cone, is the frustrum of a cone whose outline is not straight, but slightly convex; so that if it were perfect, its vertical section would have the form of a very acute pointed arch. This convexity should, however, be so slight as in the finished shaft to be hardly perceptible. Its abuse is evident in the columns of the east front of the church of St Paul, Covent Garden, and indeed in some of the less esteemed works of the Greeks themselves. The modes of fluting in the different orders may be gathered from the examples. The flutes should be deeper or shallower, as the collocation of the ordinance may require a greater or less depth of shadow on the surface of the columns. The elliptical or nearly elliptical contour seems to be the most generally pleasing. The flutes meet in an arris on columns of the Doric order, and are separated from each other by alternating fillets in the Ionic and Corinthian.

Antæ and Pilasters.—These should seldom be used, externally at least, unless with columns, for their real use is to connect a columnar ordinance with the walls to which it is attached; and being, as they are, but slight projections from walls for that purpose, nothing can be more absurd than to give them the features of columns, either by the application to them of similar capitals and bases, by diminishing, or by fluting. The use of antæ was rightly understood by the Greeks, but not by the Romans; and their proper use may be seen in the works of the former. The examples in London of their judicious application, most worthy of remark, are in those edifices already mentioned as exhibiting good specimens of the Greek orders, in the Bank of England, and in the portico only of the London University. The adaptation in these of other than the bold foliage and branching cauliculi of the columnar capitals in the Corinthian ordinances to the antæ caps is particularly worthy of notice (though they are not all of equal merit as compositions), as the Greek remains are without a regular example of Corinthian antæ, and the Roman practice is inelegant.

Pediments.—As there is no mode by which the pitch of a pediment can be determined, it must be left to the taste of the designer to be governed or not by the examples of Greek and Roman antiquity: it may, however, be premised of them generally, that those of the former school are too flat, and those of the latter too steep. The pediment of the portico of the London university is admirably proportioned to the rest of the composition, but its pitch would be absurdly flat if applied to a tetrastyle portico. The inclined sides of a pediment are covered by a cornice similar to that which forms its base, except that all blocks, modillions, and dentils are omitted, even if the bed-mould itself be retained, and a cymatium superadded.

Cornices, &c.—Although a perfect entablature should not be applied to crown an edifice, except it be in connection with columns of some sort, or their legitimate representatives, piers, yet a single cornice, or a cornice and frieze, is not so; and it forms the most pleasing termination to an elevation in which columns are not used. The proportion of one or the other may be best found by setting out a columnar ordinance of the style preferred at the height of the elevation; and the size of the cornice or cornice and frieze thus given will aptly become it. The Vignolan or block cornice, in which the frieze is occupied by cut blocks, is exceedingly effective: it is this which Sir Christopher Wren has employed in the upper Pl. LXX. entablature of St Paul's, and Vignola himself in the front Fig. 2.

Composition.

of the Villa Guilia. With these cornices rustic quoins consort very pleasingly, and so they do indeed with all single cornices which are of a bold character, and all such should be so.

Pl. LXVI. *Arcades, &c.*—The most graceful average proportion for these is, that the opening be twice the width of the pier, and twice its own width in height to the crown of the arch. The practice of the Italian school in the composition of arcaded ordinances may be generally followed with advantage, except in mingling and confusing them with columnar. The pier is based by a deep square plinth, and surmounted by a square or moulded cap or impost, the upper surface of which is the base line of the arch. In rusticated work the radiating stones of the arch show their joints, and are cut to a uniform appearance with the ordinary surface of the wall. In other cases there is a moulded archivolt, whose width varies from an eighth to a tenth of the opening of the arch. A dropping keystone is generally used; but this very much injures the simplicity, and consequently the beauty of the arch, and should be avoided.

Doors and Windows, &c.—The most approved proportion for these apertures, also, is twice their width in height. In an elevation which comprises several tiers or stories, it is customary to make those of the lowest or ground story rather less than that proportion in height; those of the first or principal story rather more; those of the second somewhat less again; and those of the third (if there be so many) square or even lower. If, however, the elevation consist of but two, the ground story should be the principal, and its windows of the most importance (if any difference be made between them at all), those of the upper story being then less than the stated proportion in height. The modes of ornamenting doors and windows are so various, and they depend so much on the coherent parts of the composition, that it is impossible here to go into their varieties, or to give particular instructions for their adaptation. The practice of the Italian school may in this case also be generally followed, avoiding those things in it which are injurious, and referring to the Greek for the details of mouldings and ornament. The application of a columnar ordinance to every door or window, giving it the effect of a little edifice in relief, exemplified by the windows of the principal story of the Farnese Palace, must be censured as injudicious; and so must pediments of all kinds, but particularly those formed with circular lines, or lines twisted in any way, or, though right lined, not meeting in a point at the apex. In basements or ground stories windows or doors may be lined with rustic courses with good effect, though the face of the wall be not rusticated; and if it be so, no other lining is thought necessary. The windows of a principal story may be lined with an architrave, either quite straight or returning in knees at the head, and resting on a continuous blocking course below. This architrave may be surmounted by an enriched frieze and cornice, the former bounded at the ends, and the latter upborne by trusses or consoles, which may rest on or be affixed to a species of pilaster, outside the architrave, and parallel to it; if detached sills are preferred, a shorter and bolder truss may be judiciously applied below the sill, under the foot of each pilaster, to complete the composition: the architrave is generally a sixth or a seventh of the opening in width, and the console and its pilaster about a ninth or tenth. Upon no account should rustics be run through the architrave lining of a window, as on the flanks of St Martin's Church in London. A series of circular-headed windows conjoined, as in the earlier works of the Venetian school, is productive of a pleasing effect; but the large circular-headed, with two conjoined smaller rectangular windows, found in the later works of the Italian school, and called Venetian, is radically inelegant; and there is such a one in the east end of the structure last mentioned. Blank windows should be recurred to as seldom as possible; and when they cannot be avoided, they should have sash-frames and sashes as if they were real windows, otherwise they give a maimed effect to an elevation.

Niches.—There are very few cases in which these do not act injuriously on a composition, from the difficulty of making them cohere with the other parts: the usual mode in Italian practice is to give them the effect of windows, which cannot be approved of. Internally they may be used with much better effect than on exteriors. If a niche is intended to receive a statue, it should have a circular head; if a vase, it will perhaps be better straight: the plan of a niche is semicircular.

Parapets.—The pierced parapet or balustrade is not inelegant when the forms of which it is composed are simple and chaste, as piers; but the close continuous parapet is generally preferable, because of its greater simplicity, and its accordance with the principles developed in the most classic works of architecture. The parapet of a projected balcony, to give an appearance of lightness, may perhaps be better pierced; but if a stereobate continue straight through a window without projection, it should remain close and uncut, unless there exist some special reason for wishing to make the window appear so much higher.

Balconies.—These, whether continuous or broken to every window, act for the most part injuriously in a composition. In the former case they cannot be kept sufficiently under not to appear of too much importance; and in the latter they have the effect of a broken cornice or entablature. In both cases, when a balcony is above the eye, it destroys the proportion of the windows opening on it, by intercepting more or less of their height.

Proportion and Arrangement of Rooms.—Whatever the length of a room may be, it will not be disagreeably proportioned if its height and breadth are the same; and if the length may be limited, once and a half the breadth is the most pleasing. Galleries, of course, will be much longer than that proportion; and corridors will necessarily be narrower than they are high. Entrance-halls should be cubical, regularly polygonal, or circular. Access should be given to a room by the end; it should be lighted on one side, and the fire-place may be at the other end, or on the other side: if the former, there should be two doors, or one and the appearance of another, that the fire-place may not be immediately opposite to a door. Many things, however, from localities and otherwise, constantly occur to make it absolutely impossible to attend to such suggestions as these. In halls and saloons not commanding a pleasing view, the windows may be advantageously placed above the usual level, for agreeable effect, for light, and for ventilation. In rooms lighted from above, as the Pantheon in Rome is, a columnar ordinance may be judiciously adapted; but otherwise columns and their accessories can seldom be well disposed internally.

Chimneys.—If a chimney be in the end of a room, it should be similarly proportioned, the height and breadth of its opening corresponding with the height and breadth of the room; if it be on a side, it should be somewhat wider than it is high; if the room be longer than the sesquialteral proportion, it should have two fire-places, either at the two ends or equidistant from the centre of one of the two sides. The chimney-piece should be bold and massive, not frittered into small parts and much moulded; it may, however, have its vertical faces enriched with great advantage.

Ceilings.—The ceiling of a room should be nearly plain,

but it may rest on a bold and enriched cornice, not composed like an external cornice, as it is differently lighted, but with deep covings instead of broad flat surfaces. Such cornices are highly susceptible of ornament, and they may have additional effect given to them by means of colour. In large rooms the area of the ceiling may be pleasingly contracted, and so made to appear lighter, by coving the angles altogether, and thus bringing the cornice on which it rests lower down on the walls. This mode of arrangement is used, too, in the small rooms of a lofty story, to take off from their too great height. The horizontal surface of a ceiling may be treated like a large panel, with broad borders and slight sinkings; or, if it be very large and lofty, coffering or panelling all over, with moulded or painted ornaments, will produce an agreeable effect. Domed ceilings should be coffered, especially when they are lighted from above; but if the light be from below, as in St Paul's and St Peter's Cathedrals, ribbing is far better. Heavy cumbrous masses of foliage in a ceiling should be avoided; frets, guiloches, and arabesque ornaments, are the best suited enrichments for a ceiling on which ornament is necessary.

Stairs.—In a structure whose principal apartments are on the ground floor, the staircase is a secondary consideration, and should be secluded; but where they are above the level of the entrance door, it becomes an important part of the interior, and should be of immediate and easy access. The rise of a step should not be more than six inches, and the tread not less than twelve. In a square staircase winders should not be used; and in no case should there be more than ten or twelve flyers without a quarter or half space, both to prevent fatigue in ascending, and to avoid even the appearance of danger in the descent. Winding staircases are less convenient and less pleasing in effect than those which are square and without winders. Much room may be saved, however, where it is of consequence, by using the former. Handrails should follow the character of the staircases to which they are attached; but a somewhat square form, with the sides or edges moulded, should be given to them under all circumstances, because of its simplicity, as well as the greater degree of firmness or solidity which the whole composition derives from it, both in effect and in appearance, than can be acquired for it otherwise. The handrail and balusters of an in-door staircase is indeed but the parapet of an external flight of steps or of a terrace, executed with more lightness and a greater degree of delicacy because of their location. The balustrading, also, should therefore be characterized by boldness and simplicity, though it is indeed a difficult thing to compose with propriety, because of its inclination, and the want of parallelism between the graduating base formed by the ends of the steps and the hanging level of the coping or handrail. The first step of a staircase has a voluted or curtail end (or ends if it be insulated, as in a staircase with a double returning flight) supporting a column or newel, on which the voluted or scrolled end of the handrail rests. The steps of a staircase are wrought with moulded nosings, which are returned at the exposed ends; the under surface is either cut straight and parallel to the inclination of the flight, or moulded to form a pleasing object when seen from below.

Mouldings and Ornament.—The Greek examples offer the most beautiful forms for mouldings, and the Grecian mode of enriching them is unsurpassed for beauty and efficiency. By adhering to them, and observing the manner in which they are produced and combined, it will not be difficult to produce and combine mouldings in sufficient variety for every purpose.

For ornament the Roman examples may vie with the Greek; but in composing or adapting, it is necessary to avoid alike the tendency to too great luxuriance in the one, and to poverty in the other. The remains of Herculaneum and Pompeii have furnished us with a great deal of ornament that is new and beautiful; and much that is excellent may be found on the earlier architectural and sculptural monuments of Italy of the middle ages.

It should nevertheless be always borne in mind that the object in architectural enrichment is not to show the ornament, but to enrich the surface, by producing an effective and pleasing variety of light and shade; but still, although the ornament should be a secondary consideration, it will develope itself, and should therefore be of elegant form and composition, as well as the means of producing a good effect on the architecture to which it is attached.

Of Vertical or Pointed Composition.

The towers of Westminster Abbey are an excellent practical illustration of the essential difference which exists between the horizontal and vertical styles of architectural composition. In general form they belong to the Pointed style, and in so far cohere with the structure generally; but the running lines of the buttresses, if their angle piers may be so called, are constantly intercepted by transverse cornices; and all the details are strangely in discordance with the character derived from the pointed arch.

Buttresses in a Pointed composition must not be considered simply as buttresses, or supports to the angles, or sides of a structure, any more than a cornice in horizontal composition may be thought only necessary to cover or protect the wall on which it rests. That these were the uses for which they were severally applied originally, cannot perhaps be doubted; but although they may be useful as such, we must now consider them as aids to architectural effect. Buttresses, then, are of the same use in the vertical style that cornices are in the horizontal—to give character to an elevation, by throwing a mass of shadow, to relieve it of the monotony necessarily attendant on a flat surface, however it may be pierced or enriched. The sides of the buttresses should be either quite perpendicular the whole height they have to run, or be slightly diminished, if the wall behind them diminishes, in lengths and not by inclined lines. Their faces also must run up vertically to the sets-off, and these should be in the same inclined line, and that line pointing to the apex of their pinnacles, when pinnacles surmount them. Indeed it cannot be too strongly enforced that there should be a constant tendency in the outlines of compositions in this style to meet, although the surfaces be themselves so generally perpendicular; and the more acute the angle under which they incline, the more graceful and becoming the style the result will be. The commanding lines of every part of a composition should lead through from its summit to the base. Thus, a spire or pinnacle should rest on a tower or turret whose angles are not interrupted, but never on a merely flat wall, however it may be faced with buttresses to give an apparent projection. Neither should low porches be projected from the face of a structure, for such can only have the effect of excrescences, and tend to injure a composition; nor should external doors be made but in places where the harmony of the composition is not injured by them as irregular apertures. Internally, square forms are seldom used; but piers consist of clustered cylindrical shafts, and thin shafts of the same form, lofty, and uninterrupted by crossing lines, act as pilasters. On these, capped with deeply inflected congeries of mouldings or foliage for the former, and lighter ones made continuous and breaking round them for the latter, rest the arches and arched ceilings. Flat surfaces are susceptible of high enrichment by means of tracery and panelling;

Glossary.

mouldings are enriched, not by carving on them, but by rounding out foliage and other ornament in covings and other deep inflections. Corbels should not be substituted for shafts to support arches when it can be avoided; but they have a pleasing effect as supports to the dripstone or canopy of a door or window; and indeed there are many other situations in which they are almost necessary, but they should always be considered as succedaneous, and not as necessary to a composition.

To avoid glaring inconsistencies in composing, it will be well to adhere generally to the style of some particular period, and to employ the proportions and enrichments, as well as the forms, peculiar to it; but, nevertheless, a more ornate may superimpose a plainer part, so that the difference be not violent. Windows of the second period may be placed over an arched composition of the first, and appear naturally to result from it; but the transition would be so great from the first to the third, as to make the result inharmonious. It need not however be denied, to those who feel themselves competent to use the materials with good taste and propriety, to select matter from examples of the various periods, and make compositions not exactly in the style of any of them. With a clear perception of the principles of the style generally, which we have endeavoured to point out, and a practical acquaintance with the classic exemplars of it, such may certainly be produced; and they may as certainly be adapted to all the purposes to which any species of architecture can be applied.

Rules for practice might be made to infinity, but they are unnecessary in this case, there being no authorized modern practice, like that of the Italian school in horizontal composition, to counteract. It is but to use the forms, proportions, decorations, and enrichments, and follow the mode of combination, which appear in the examples: these, with constant reference to the principles we have attempted to develope, will be the surest and safest guides in composing and arranging any subject. They are, too, so rife with materials for general purposes, that few cases can occur in which there need be any difficulty in finding parallels. Buttresses, piers, shafts, arches, pediments, parapets, turrets, pinnacles, windows, doors, niches, ceilings, tablets, with mouldings and ornaments in great profusion,—indeed almost every thing that can be required in practice,—appear in existing works of the style; preventing the necessity of determining from the mode of procedure in one case how we should act in another, as the comparative paucity of materials in the Greek and Roman remains rendered it necessary to do in developing the horizontal style. (H. H.)

Errata.—P. 421, 1st col. note, *for* Pl. LXXI. *read* LXXIV.; p. 423, 2d col. line 31, *for* Gothic *read* Goth; p. 435, note, *for* p. 331 *read* 416.

GLOSSARY OF NAMES AND TERMS USED IN ARCHITECTURE.[1]

Abaciscus (diminutive of Abacus, *q. v.*). This term is applied to the chequers or squares of a tessellated pavement.

Abacus (Gr. αβαξ, a square tile or table). The rectangular and equilateral tablet covering the ovalo of the capital of the Doric column, and on which the superimposed entablature rests, is called the abacus; and from it the similar part (though differently shaped) of all capitals is distinguished by the same term. Abacus means the same thing, but is opposed in application to Plinth, *q. v.* See also Plate LXVI. fig. 1.

Acroterium (Gr. ακρωτηριον, the summit or vertex), a statue or ornament of any kind placed on the apex of a pediment. The term is often incorrectly restricted to the plinth, which forms the podium merely for the acroterium. The statue of the saint on the apex of the pediment of the western front of St Paul's is an acroterium; the other statues may be called acroteral figures.

Amphiprostyle (Gr. αμφι, around or about, and *prostyle*, q. v.). A temple with a portico at each end is said to be an amphiprostyle. This term would be more correctly applied to a structure having projecting porticoes on all its sides, especially if it be equilateral like the *Bourse* or Exchange at Paris, allowing no distinction of flanks or wings to make it peripteral. See Plate LIX. fig. 3 and 4, and Description, page 472.

Annulet (Lat. *annulus*, a ring). This term is applied to the small fillets or bands which encircle the lower part of the Doric capital immediately above the neck or trachelium.

Antæ (probably from the Gr. αντιος, or some other compound of the preposition αντι, for, or opposite to; it has no singular), the pier-formed ends of the walls of a building, as in the portico of a Greek temple. A portico is said to be *in antis* when columns stand between antæ, as in the temple of Theseus, supposing the peristyle or surrounding columns removed. Plate LVIII. fig. 1, 2, and 3.

Antefixæ (Lat. *ante*, before, and *fixus*, fixed), upright blocks with an ornamented face placed at regular intervals on a cornice. Antefixæ were originally adapted to close and hide the lower ends of the joints of the covering tiles on the roof of a temple as they appear in the examples. Plate LVII. fig. 1, 2, and 4; and Plate LIX. fig. 3.

Apophyge (Gr. αποφυγη, a flying off), the lowest part of the shaft of an Ionic or Corinthian column, or the highest member of its base if the column be considered as a whole. The apophyge is the inverted cavetto or concave sweep, on the upper edge of which the cylindrical shaft rests. Plate LXVI. fig. 1.

Apteral (Gr. α priv. and πτερον, a wing), a temple without columns on the flanks or sides. The Greek Ionic temple, Plate LIX., is apteral.

Aræostyle (Gr. αραιος, rare or weak, and στυλος, a column), a wide intercolumniation. (See Eustyle.) The space assigned to this term is four diameters.

Aræosystyle (compounded of *aræostyle* and *systyle*, q. v.). This term is used to express the arrangement attendant on coupled columns, as in the western front of St Paul's Cathedral. Plate LXVIII. fig. 1.

Arcade, a series of arches.

Arch (Lat. *arcus*, a bow), a construction of separate or distinct blocks or masses of any hard material, cut wedge-wise, and arranged in a bowed form, so as to bear from end to end horizontally, or across an opening, though abutting or being supported only at the ends.

Architrave (Gr. αρχη, chief, and Lat. *trabs*, a beam), the chief beam,—that part of the entablature which rests immediately on the heads of the columns, and is surmounted by the frieze: it is also called the epistylium or epistyle. Plate LXVI. fig. 1. The moulded enrichment on the sides and head of a door or window is called an architrave.

Archivolt. This term is a contraction of the Italian

[1] Those marked thus † are either entirely, or almost entirely, peculiar to Pointed Architecture.

architrave voltato. It is applied to the architrave moulding on the face of an arch, and following its contour.

Arris, the sharp edge or angle in which two sides or surfaces meet.

Astragal (Gr. αστραγαλος, a vertebral joint), a convex moulding. This term is generally applied to small mouldings, and torus to large ones of the same form. (See Torus.)

Attic, a low story above an entablature, or above a cornice which limits the height of the main part of an elevation. The etymology of this term is unsettled: probably the upper range of columns in a Greek hypæthral temple (see Plate LVII. fig. 1) was called ατειχον, from having no coherent wall; whence the Latin *atticum*, and its application to a story superimposing the general ordinance. Otherwise such a thing is unknown in Greek architecture; but it is very common in both Roman and Italian practice. What is here termed the tholobate in St Peter's and St Paul's cathedrals are generally termed attics.

Baluster, a small column or pier supporting the coping in a pierced parapet: the parapet itself when pierced is hence called a balustrade.

Band or Tænia, nearly synonymous with Fillet, *q. v.* This term is, however, most generally applied to that listel in the Doric entablature which separates the frieze from the architrave, and connects the lower parts of the triglyphs.

Base (Gr. βασις, from the verb to bear). The congeries of mouldings generally placed under the shaft of an Ionic or Corinthian column is called its base. Plate LXVI. fig. 1. The term is applied also to the lowest part of a pedestal or stylobate; to the vertical moulded fittings which go round walls on the floor; and generally to every thing that is put lowest, for any thing to rest on.

Batter (Fr. *battre*, to beat). Building over in projecting courses, like inverted steps, is termed battering, beating, or corbelling over.

† Battlement, a pierced or machicolated parapet.

† Bay. The space between the mullions of a window, between piers, and between the principal beams of a roof, floor, or ceiling, is a bay.

Bead, a small cylindrical moulding of frequent use. Plate LXI.

Bed-mould, the congeries of mouldings which is under the projecting part of almost every cornice, and of which indeed it is a part. Plate LXVI. fig. 1.

Blocking-course, a deep but slightly projecting course in an elevation, to act as cornice to an arcade, or to separate a basement from a superior story. (See String-course.)

† Boss, a sculptured knob which is placed on the intersections of ribs in groined ceilings.

† Buttress, the projected piers against the angles of towers, and against the ordinary piers of walls, to strengthen them, and receive the outward thrust of the inner transverse arches.

Cabling. The flutes of columns are said to be cabled when they are partly occupied by solid convex masses, or appear to be refilled with cylinders after they had been formed.

† Canopy, a covering or hood, the enriched projecting head to a niche or tabernacle. The tablet or drip-stone, whether straight or circular, over the heads of doors or windows, if enriched, is called a canopy

Capital, Cap (Gr. κεφαλη, the head), the spreading, moulded, voluted, foliate, or otherwise enriched head of a column. Plate LXVI. fig. 1. The term *cap* is applied, in contradistinction, to the congeries of mouldings which forms the head of a pier or pilaster.

Caryatides. Human female figures used as piers, columns, or supports, are called *Caryatides;* and, adjectively, *Caryatic* is applied to the human figure generally, when used in the manner of Caryatides. Plate LX. fig. 4 and 6.

Cassoon (Ital.), a deep panel or coffer in a soffit or ceiling. This term is often written, after the French *caisson*, whereas we derive it directly from the Italian *cassone*, the augmentative of *cassa*, a chest or coffer.

Cathetus (Gr. καθετος, a perpendicular line). The eye of the volute is so termed because its position is determined, in an Ionic or voluted capital, by a line let down from the point in which the volute generates.

Cauliculus (Lat. a stalk or stem), the inner scrolls or tendrils of the Corinthian capital are called *Cauliculi.* It is not uncommon, however, to apply this term to the larger scrolls or volutes of the same also. Plate LXVI. fig. 1.

Cavetto (Ital. *cavare*, to dig out), a moulding whose form is a simple concave, and impending. Plate LXI.

Cella (Lat.), the cell or interior of a Cleithral temple. The Greek term is Naos, *q. v.*

Chamfer. An edge or arris taken off equally on the two sides which form it, leaves what is called a *chamfer*, or a *chamfered edge.* If the arris be taken off more on one side than the other, it is said to be splayed or bevelled.

† Cinquefoil, tracery in five foliations or featherings. The windows in the towers of Westminster Hall, Plate LXXV., are cinquefoiled.

Cleithral (*vide* Cleithros). This is used of a covered Greek temple, in contradistinction to *Hypæthral*, which designates one that is uncovered.

Cleithros (Gr. κλειθρος, an inclosed or shut up place). A temple whose roof completely covers or incloses it is a Cleithros. Plate LVIII. fig. 1, 2, 3; and Plate LIX. fig. 1, 2, 3, and 4.

Coffer, a deep panel in a ceiling.

Column (Lat. *columna*), a tapering cylindrical mass, placed vertically on a level stylobate, in some cases with a spreading congeries of mouldings called a base, and having always at its upper and smaller end a dilating mass called a capital. Columns are either insulated or attached. They are said to be attached or engaged when they form part of a wall, projecting one half or more, but not the whole of their substance. Plate LIX. fig. 1 exhibits insulated, and fig. 2 attached columns. See also Plate LXVI. fig. 1.

Consol or Console, a bracket or truss, generally with scrolls, or volutes, at the two ends, of unequal size and contrasted, but connected by a flowing line from the back of the upper one to the inner convolving face of the lower.

Coping, the covering course or cornice of a wall or parapet. The term *coping* is generally applied to a plain, slightly projected, covering course, and *cornice* to a larger moulded coping.

† Corbel, a knob, boss, or consol, projecting from a vertical face, to act as a prop or support. Its jutting or overhanging has induced the application of the term to describe the projection of one thing over another.

Cornice (Gr. κορωνις, the highest part, that which is placed last on a building), the highest part of an entablature—that which rests on the frieze. Plate LXVI. fig. 1. The term *cornice* is very generally applied to any bold congeries of mouldings occupying the highest

place in a composition, whether external or internal. A plain covering to a wall or parapet is called a coping, *q. v.*

Corona (*vide* Cornice). This term is applied to the deep vertical face of the projected part of the cornice between the bed-mould and the covering mouldings. Plate LXVI. fig. 1.

† Crocket (probably from the old English word *crok*, a curl), an ornament of foliage or animals running up the back of a pediment, arch, pinnacle, or spire, from the corbels below to the finial above, in which latter the crockets on both sides appear to merge. Plate LXXV. fig. 3 and 5. In the earlier examples the crocket is a mere curl, or bent tendril, with an enriched end.

Cupola (Ital. *cupo*, concave, profound), a spherical or spheroidal covering to a building, or to any part of it. Plate LXIV. fig. 2, 3, and 4; Plate LXIX.; and Plate LXXIV. fig. 2.

† Cusp (Lat. *cuspis*, a spear), the points in which the foliations of tracery finish. These are sometimes themselves enriched, and are sometimes plain.

Cyclostylar (Gr. κυκλος, a circle, and στυλος, a column). A structure composed of a circular range of columns without a core is cyclostylar, for with a core the range would be a peristyle. This is the species of edifice falsely called by Vitruvius Monopteral. (See Monopteros.)

Cyma (Gr. κυμα, a wave), the name of a moulding of very frequent use. It is a simple, waved line, concave at one end and convex at the other, like an Italic *f*. In that manner it is called a cyma-recta; but if the convexity appear above, and the concavity below on the right hand, it is then a cyma-reversa. Plate LXI.

Cyrtostyle (Gr. κυρτος, convex, and στυλος, a column), a circular projecting portico. Such are those to the transept entrances to St Paul's cathedral, Plate LXIX. fig. 1.

Dado or Die, the vertical face of an insulated pedestal, between the base and cornice or surbase. It is extended also to the similar part of all stereobates which are arranged like pedestals in Roman and Italian architecture.

Decastyle (Gr. δεκα, ten, and στυλος, a column), a portico of ten columns in front. (See note to the term Hexastyle.) The portico to the London University is of this description; more particularly described, it is deca-prostyle and recessed.

Dentil (Lat. *dens*, a tooth). The cogged or toothed member, so common in the bed-mould of a Corinthian entablature, is said to be dentilled; and each cog or tooth is called a dentil. Plate LXVI. fig. 1.

Design. Architects apply this term to what is vulgarly called a plan, intending by it the scheme or design of a building in all its parts, the term *plan* having a distinct application to a technical portion of the design. (See Plan.) The plans, elevations, sections, and whatever other drawings may be necessary for an edifice, exhibit the design.

Detail. As used by architects, detail means the smaller parts into which a composition may be divided. It is applied generally to mouldings and other enrichments, and again to their minutiæ.

Diameter (superior and inferior). The greater diameter of the shaft of a column is technically termed its inferior, because it is that of the lower end; and the lesser, that of the upper end, its superior diameter.

Diastyle (Gr. δια, through, and στυλος, a column), a spacious intercolumniation, to which three diameters are assigned. (*Vide* Eustyle.)

Dipteral. (See Dipteros.)

Dipteros (Gr. δις, twice, and πτερον, a wing), a double winged temple. The Greeks are said to have constructed temples with two ranges of columns all round, which were called dipteroi. A portico projecting two columns and their interspaces is of dipteral or pseudo-dipteral arrangement. See description of fig. 3, Plate LVIII. page 472.

Distyle (Gr. δις, twice, and στυλος, a column), a portico of two columns. This term is not generally applied to the mere porch with two columns, but to describe a portico with two columns in antis. The elevation of the pronaos of the hexastyle peripteral temple, Plate LVIII. fig. 2, exhibits an example of distyle in antis.

Ditriglyph (Gr. δις, twice, and triglyph, *q. v.*), an intercolumniation in the Doric order, of two triglyphs. (See Monotriglyph.)

Dodecastyle (Gr. δωδεκα, twelve, and στυλος, a column), a portico of twelve columns in front. (See note to Hexastyle.) There is no portico of this description in London at present. The lower one of the west front of St Paul's Cathedral (Plate LXVIII.) is of twelve columns, but they are coupled, making the arrangement pseudo-dodecastyle. (See Pseudo-Prostyle.) The Chamber of Deputies in Paris has a true dodecastyle.

Dome (Gr. δωμα, a structure of any kind; whence the Latin *domus*, a house or temple), a cupola or inverted cup on a building. The application of this term to its generally received purpose is from the Italian custom of calling an archiepiscopal church, by way of eminence, *Il duomo*, the temple; for to one of that rank, the cathedral of Florence, the cupola was first applied in modern practice. The Italians themselves never call a cupola a dome: it is on this side the Alps the mistake has arisen, from the circumstance, it would appear, that the Italians use the term with reference to those structures whose most distinguishing feature is the cupola, tholus, or (as we now call it) dome. (See Cupola.)

† Dripstone, the moulding or cornice which acts as a canopy to doors and windows. Horizontal running mouldings are sometimes called tablets and sometimes dripstones.

Drops. (See Guttæ.)

Echinus (Gr. εχινος, an egg), a moulding of eccentric curve, which (when it is carved) being generally cut into the forms of eggs and anchors alternating, the moulding is called by the name of the more conspicuous. It is the same as Ovalo, *q. v.*

Elevation, the front, or *façade* as the French term it, of a structure. A geometrical drawing of the external upright parts of a building. Architects speak of front, back-front, and side or end elevations.

Entablature or Intablature (Lat. *in*, upon, and *tabula*, a tablet). The superimposed horizontal mass in a columnar ordinance, which rests upon the tablet or abacus of a column, is so called. It is conventionally composed of three parts, architrave, frieze, and cornice, *q. v.* Plate LXVI. fig. 1.

Entasis (Gr. εντασις, a stretching or swelling). Columns are said to have entasis when they do not diminish regularly, but in a curved line. (See page 461.)

Epistylium or Epistyle (Gr. επι, upon, and στυλος, a column). This term may with propriety be applied to the whole entablature, with which it is synonymous; but it is restricted in use to the architrave or lowest member of the entablature.

Escape, a term sometimes used for the apophyge of a column. (See Apophyge.)

Eustyle (Gr. ευ, well, and στυλος, a column), a species of intercolumniation, to which a proportion of two dia-

meters and a quarter is assigned. This term, together with the others of similar import,—pycnostyle, systyle, diastyle, and aræostyle,—referring to the distances of columns from one another in composition, is from Vitruvius, who assigns to each the space it is to express. It will be seen, however, by reference to them individually, that the words themselves, though perhaps sufficiently applicable, convey no idea of an exactly defined space, and by reference to the columnar structures of the ancients, that no attention was paid by them to such limitations. It follows, then, that the proportions assigned to each are purely conventional, and may or may not be attended to without vitiating the power of applying the terms. Eustyle means the best or most beautiful arrangement; but as the effect of a columnar composition depends on many things besides the diameter of the columns, the same proportioned intercolumniation would look well or ill, according to those other circumstances; so that the limitation of eustyle to two diameters and a quarter is absurd, and so it is in the case of the other similar terms. With Doric intercolumniation it is different, as may be seen by reference to the word MONOTRIGLYPH.

FAÇADE. (See ELEVATION.)

FASCIA (Lat. a band). The narrow vertical bands or broad fillets into which the architraves of Corinthian and Ionic entablatures are divided, are called fasciæ or fascias; and the term is generally applied to any similar member in architecture.

† FEATHERINGS. (See FOLIATIONS.)

FILLET, a narrow vertical band or listel, of frequent use in congeries of mouldings, to separate and combine them, and also to give breadth and firmness to the upper edge of a crowning cyma or cavetto, as in an external cornice. The narrow slips or breadths between the flutes of Corinthian and Ionic columns are also called fillets.

† FINIAL (Lat. *finis*, the end). This term is equivalent to the Greek Acroterium. It is applied to the carved apex of pediments, piers, pinnacles, and canopies.

FLUTE, a concave channel. Columns whose shafts are channelled are said to be fluted, and the flutes are collectively called flutings.

† FOLIATIONS or FEATHERINGS, small arches meeting in points or cusps, which are plain or enriched. They are used as an enrichment in tracery, and are distinguished as trefoils, quatrefoils, and cinquefoils, as the case may be.

FRIEZE (Ital. *fregio*, from the Lat. *phrygionius*, enriched or embroidered), that portion of an entablature between the cornice above and the architrave below. Plate LXVI. fig. 1. It derives its name from being the recipient of the sculptured enrichments either of foliage or figures which may be relevant to the object of the structure. The frieze is also called the zoöphorus, *q. v.*

FRONTISPIECE, the front or principal elevation of a structure. This term, however, is generally restricted in application to a decorated entrance.

GABLE. When a roof is not hipped or returned on itself at the ends, its ends are stopped by carrying up the walls under them in the triangular form of the roof itself. This is called the gable, or, indeed, the pediment. The latter term, however, is restricted to the ornamental and ornamented gable; and gable itself is applied to a plain triangular end.

GRADINO (Ital. dim. of *gradus*, a step). Architects frequently use the plural of this term, gradini, and to gradinate, instead of the English, steps, and to graduate, perhaps without sufficient reason, though they find them useful to distinguish what they intend from the meaning of the latter words in their ordinary acceptation.

GROINING. In vaulting or arching over from insulated piers, the cross vaults meet in angles, and lead to a common centre or apex. This is called groining.

GUILOCHE or GUILOCHOS (Gr. γυιον, a member, and λοχος, a snare). An interlaced ornament like network, used most frequently to enrich the torus. Plate LXI.

GUTTÆ (Lat. drops). The small cylindrical drops used to enrich the mutules and regulæ of the Doric entablature are so called.

HELIX (Gr. ἑλιξ, a wreath or ringlet), used synonymously with Cauliculus, *q. v.* It forms in the plural Helices.

HEMIGLYPH (Gr. ἡμισυς, half, and γλυφη, an incision or channel). The half-channels, or rather chamfered edges, of a triglyph tablet, may be so called. The two hemiglyphs are included to make the third channel, and complete the triglyph. (See TRIGLYPH.)

HEXASTYLE (Gr. ἑξ, six, and στυλος, a column). A portico of six columns in front[1] is of this description. Most of the churches in London which have porticoes have hexa-prostyles. (See PROSTYLE.)

HYPÆTHRAL. (See HYPÆTHROS.)

HYPÆTHROS (Gr. ὑπο, under, and αιθρα, the air), a temple open to the air, or uncovered. The Greeks frequently made the temples of the supreme divinities hypæthral. For instance, those of Jupiter Olympius at Agrigentum in Sicily, of Neptune at Pæstum, and of Minerva Parthenon at Athens, are all of this description. The term may be the more easily understood by supposing the roof removed from over the nave of a church in which columns or piers go up from the floor to the ceiling, leaving the aisles still covered. In that case it would be hypæthral, after the manner of the Greek hypæthros. The Pantheon in Rome having an opening in the centre of the dome, is thereby rendered hypæthral. See Plates LVII. and LXIV. fig. 4 and 5.

HYPOGEA (Gr. ὑπο, upon, and γη, the earth). Constructions under the surface of the earth, or into the sides of a hill or mountain, are hypogea.

HYPOTRACHELIUM (Gr. ὑπο, upon, and τραχηλος, the neck), the part forming the junction of the shaft with the capital of a column; the neck of the capital itself. In some styles it is a projecting fillet or moulding, and in others, as the Doric, it is composed of a channel or groove, and sometimes of more than one. Plate LXVI. fig. 1.

JAMB, the side-post or lining of a door-way or other aperture. The jambs of a window outside the frame are called reveals.

ICHNOGRAPHY (Gr. ιχνος, a footstep or track, and γραφη, a description or representation). A plan, or the representation of the site of an object on a horizontal plane, is its ichnography. The term plan (*q. v.*) is, however, much more frequently used than this.

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[1] The words "in front" are used to prevent the mistake which might arise from a supposition that all the columns in a portico should be counted to designate it. The porticoes of the churches of St Martin in the Fields, and St Mary-le-bone, in London, for instance, have eight columns each, but are hexastyle, there being but six in their front rows.

Glossary.

IMPOST (Lat. *impositus*, laid upon). The horizontal congeries of mouldings forming the capital of a pier, or edge pilaster, which has to support one leg of an arch, is called the impost; sometimes, and more conveniently, this term is used for the pilaster itself, when its capital is called the impost cap or impost mouldings.

INTERCOLUMNIATION (Lat. *inter*, between, and column, *q. v.*). The distance from column to column, the clear space between columns, is called the intercolumniation.

† LABEL, the level moulding or dripstone over a door or window, common in the later Pointed works. It is generally turned down at the ends at right angles, and slightly returned again horizontally and outwards.

LACUNAR (Lat.), a panelled or coffered ceiling or soffit. The panels or cassoons of a ceiling are more classically called *lacunaria*.

† LANTERN (Lat. *lanterna*), a turret raised above a roof or tower, and very much pierced, the better to transmit light. In modern practice this term is generally applied to any raised part in a roof or ceiling, containing vertical windows, but covered in horizontally.

METOPE (Gr. μετοπη, a middle space), the square recess between the triglyphs in a Doric frieze. It is sometimes occupied by sculptures. Plates LVII. and LVIII. fig. 4.

MEZZANINE (Ital. *mezzanino*, dim. of *mezzo*, the middle), a low story between two lofty ones. It is called by the French entresol, or inter-story.

MODILLION (Lat. *modulus*, a measure of proportion), so called because of its arrangement in regulated distances; the enriched block or horizontal bracket generally found under the cornice of the Corinthian entablature. Plate LXVI. fig. 1. Less ornamented, it is sometimes used in the Ionic. See also MUTULE.

MODULE (Lat. *modulus, à modus*, a measure or rule). This is a term which has been generally used by architects in determining the relative proportions of the various parts of a columnar ordinance. The semidiameter of the column is the module, which being divided into thirty parts called minutes, any part of the composition is said to be of so many modules and minutes, or minutes alone, in height, breadth, or projection. The whole diameter is now generally preferred as a modus, it being a better rule of proportion than its half.

MONOPTERAL. (See MONOPTEROS.)

MONOPTEROS (Gr. μονος, one, or single, and πτερον, a wing). This term is incorrectly used by Vitruvius to describe a temple composed of a circular range of columns supporting a tholus, cupola, or dome, but without walls. (See PERIPTERAL.) Such an edifice would be more correctly designated as Cyclostylar, *q. v.*

MONOTRIGLYPH (Gr. μονος, one, or single, and *triglyph*, q. v.). The intercolumniations of the Doric order are determined by the number of triglyphs which intervene, instead of the number of diameters of the column, as in other cases; and this term designates the ordinary intercolumniation of one triglyph. Plate LVIII. fig. 1.

MOULDINGS, eccentric curves of various kinds, intended to enrich and ornament, by producing light and shade, and obviating the monotony attendant on many flat and angular surfaces. They may be variously carved to increase their efficiency. The most usual forms of mouldings are called the cyma-recta and reversa, cavetto, scotia, torus, astragal or bead, and the echinus or ovalo, *q. v.* Plate LXI. In Pointed architecture, mouldings are not limited either to those names or to the forms they are intended to designate, nor indeed is any other style, except by absurd custom and authority.

† MULLION, the columnar vertical bar used to divide a window into breadths; the trunk out of which tracery flows.

MUTULE (Lat. *mutulus*, a stay or bracket), the rectangular impending blocks under the corona of the Doric cornice, from which guttæ or drops depend. Mutule is equivalent to modillion, but the latter term is applied more particularly to enriched blocks or brackets, such as those of Ionic and Corinthian entablatures.

NAOS (Gr. ναος, a temple). This term is sometimes used instead of the Latin Cella, as applied to the interior; strictly, however, it means the body of the edifice itself, and not merely its interior or cell.

NEWEL, the solid or hollow column or cylinder which bears up the handrail of a staircase at the foot and in the most material parts. It means also the core or hollow, as the case may be, about which a circular staircase winds.

NICHE, a concave recess in a wall, with a straight or circular head. Niches are generally made to receive statues, vases, &c.

OCTASTYLE (Gr. οκτω, eight, and στυλος, a column). A portico of eight columns in front. (See note to HEXASTYLE.) There is no portico in London of this description at present, though the upper one of the west front of St Paul's (Plate LXVIII.) is of eight columns; but they are coupled, making the arrangement tetrastyle. It may indeed be called a pseudo-octa-prostyle. (See PSEUDOPROSTYLE.)

OGEE, the vulgar name for the Cyma, *q. v.*

OPISTHODOMUS (Gr. οπισθεν, behind, and δομος, a house or other edifice), the part behind a Greek temple corresponding with the Pronaos before it. (See PRONAOS.)

ORDER. A column with its entablature and stylobate is so called. (Plate LXVI. fig. 1.) The term is the result of the dogmatic laws deduced from the writings of Vitruvius, and has been exclusively applied to those arrangements which they were thought to warrant.

ORDINANCE, a composition of some particular order or style. It need not, however, be restricted to a columnar composition, for it will apply to any species which is subjected to conventional rules for its arrangement.

ORTHOGRAPHY (Gr. ορθος, straight or true, and γραφη, a description or representation). A geometrical elevation of a building or other object, in which it is represented as it actually exists, or may exist, and not perspectively, or as it would appear, is called its orthography.

ORTHOSTYLE (Gr. ορθος, straight or true, and στυλος, a column), any straight range of columns. This is a term suggested to designate what is generally but improperly called a peristyle, *q. v.*; that is, columns in a straight row or range, but not forming a portico.

OVALO (Ital.), egg-formed (see ECHINUS). This is the name most commonly applied to the moulding which appears to have originated in the moulded head of the Doric column, and, with an abacus, forming its capital.

PANEL, a compartment with raised margins, moulded or otherwise. Deep panels in a ceiling are called Cassoons and Lacunaria, *q. v.*

PARAPET (Ital. *parapetto*, against the breast, or breast-high), the low breast-high wall which is used to front terraces and balconies, to flank bridges, &c. The most common application of the term in this country is to so much of the external walls of a house as stands above the level gutters of the roof behind.

PARASTAS (Gr. παραστας, standing before), an antæ or end pilaster. This is the Greek term for which the Latin antæ is generally used, and it has the same meaning. (See ANTÆ.)

PEDESTAL (Gr. πους, a foot, and στυλος, a column). An insulated stylobate is for the most part so called. The term is, moreover, generally applied to any parallelogramic or cylindrical mass used as the basement of any single object, as a statue or vase.

PEDIMENT, that part of a portico which rises above its entablature to cover the end of the roof, whose triangular form it takes. The cornice of the entablature, or its corona and part of the bed-mould only, with the addition of a cymatium, bounds its inclined sides, and joins in an obtuse angle at the apex. In Pointed architecture, however, the angle of a pediment is for the most part acute.

† PENDENT (Lat. *pendens*, hanging). In some of the later works of the Pointed style, large masses depend from enriched ceilings, and appear to be formed by the other legs of intersecting arches: these are called pendents. They also occur in canopies. See Plate LXXV. fig. 1, 8, 9, 11, and 12.

PERIBOLUS (Gr. περι, around or about, and βαλλω, to gird or throw around), an inclosure. Any inclosed space is a peribolus; but the term is applied more particularly to the sacred inclosure about a temple. The wall forming the inclosure is also called the peribolus.

PERIPTERAL. (See PERIPTEROS.)

PERIPTEROS (Gr. περι, around or about, and πτερον, a wing). A temple or other structure with the columns of its end, prostyles or porticoes, returned on its sides or wings, and one intercolumniation distant from the walls. Almost all the Doric temples of the Greeks were peripteral. The term is, however, incorrectly applied by Vitruvius to peristylar structures, though it is clear that a perfectly round building, such as he describes to be peripteral, cannot be said to be winged or to have wings.

PERISTYLAR, having a peristyle. (See PERISTYLE.)

PERISTYLE (Gr. περι, around or about, and στυλος, a column), a range of columns encircling an edifice, such as that which surrounds the cylindrical drum under the cupola of St Paul's. The columns of a Greek peripteral temple form a peristyle also, the former being a circular and the latter a quadrilateral peristyle. The same term is generally but incorrectly applied to a range of columns in almost any situation when they do not form a portico. (See ORTHOSTYLE.)

PIER. The solid parts of a wall between windows, and between openings generally, are called piers. The term is also applied to masses of brickwork or masonry, which are insulated to form supports to gates or to carry arches.

PILASTER (Lat. *pila*, a pillar, and the Ital. augmentative *astro*, which indicates an inferior quality), an inferior sort of column or pillar; a projection from or against a pier, having the form and decorations of antæ, when used correctly; but too frequently they have capitals, like those of columns, assigned them.

PILLAR (Lat. *pila*, and Ital. *piliere*), a columnar mass of no particular form. Columns are vulgarly called pillars; but architects make a distinction, restricting this term to such pillars as do not come within the description of a column. (See COLUMN.)

PILLOWED. A swollen or rounded frieze is said to be pillowed or pulvinated.

† PINNACLE, the slender tapering head of a turret or buttress. A small spire, or the head of a spire or steeple.

PLAN, a horizontal geometrical section of the walls of a building; or indications, on a horizontal plane, of the relative positions of the walls and partitions, with the various openings, such as windows and doors,—recesses and projections, as chimneys and chimney-breasts,—columns, pilasters, &c. This term is often incorrectly used in the sense of DESIGN, *q. v.*

PLANCEER is sometimes used in the same sense as soffit, but incorrectly, as it is from the French *plancher*, to board or floor. It is more particularly applied to the soffit of the corona in a cornice.

PLINTH (Gr. πλινθος, a square tile). In the Roman orders the lowest member of the base of a column is square and vertically faced; this is called a plinth.

POLYTRIGLYPH (Gr. πολυς, many, and triglyph, *q. v.*). An intercolumniation in the Doric order of more than two triglyphs. (See MONOTRIGLYPH and DITRIGLYPH.)

PORTICO (an Italicism of the Lat. *Porticus*), an open space before the door or other entrance to any building, fronted with columns. A portico is distinguished as prostyle, or in antis, as it may project from or recede within the building, and is designated with either of these terms by the number of columns its front may consist of. (See DISTYLE, TETRASTYLE, HEXASTYLE, OCTASTYLE, &c.)

PORTICUS (Lat. See PORTICO). In an amphiprostylar or peripteral temple, this term is used to distinguish the portico at the entrance from that behind, which is called the posticum.

POSTICUM (Lat.). A portico behind a temple. (See PORTICUS and PORTICO.)

PRONAOS (Gr. προ, before, and ναος, a temple). The inner portico of a temple, or the space between the porticus, or outer portico, and the door opening into the cella. This is a conventional use of the term; for, strictly, the pronaos is the portico itself.

PROPYLÆUM (Gr. προ, before, and πυλη, a portal), any structure or structures forming the entrance to the peribolus of a temple; also the space lying between the entrance and the temple. In common usage this term, in the plural (propylæa), is almost restricted to the entrance to the Acropolis of Athens, which is known by it as a name.

PROSTYLE (Gr. προ, before, and στυλος, a column). A portico in which the columns project from the building to which it is attached is called a prostyle. It is tautologous to say a prostyle portico,—a prostyle is a portico. Custom, however, seems to warrant the impropriety, for the word portico is always superadded. In determining the number of columns of which a portico consists, the Greek numerals are prefixed to the term Style, *q. v.*, and prostyle is repeated. It would be more concise, and, at the least, equally correct, to put the numeral before prostyle, and say tetra-prostyle, hexa-prostyle, &c. instead of tetrastyle-prostyle, &c.; as the custom is; that mode is adopted in this article throughout.

PSEUDO-DIPTERAL (Gr. ψευδης, false, and dipteral, *q. v.*), false double-winged. When the inner row of columns of a dipteral arrangement is omitted, and the space from the wall of the building to the columns is preserved of the consequent double projection, it is pseudo-dipteral. The portico of the London University is pseudo-dipterally arranged, the returning columns on the ends or sides not being carried through behind those in front.

PSEUDO-PERIPTERAL (Gr. ψευδης, false, and peripteral, *q. v.*), false-winged. A temple having the columns on its flanks attached to the walls, instead of being arranged as in a peripteros, is said to be pseudo-peripteral.

PSEUDO-PROSTYLE (Gr. ψευδης, false, and prostyle, *q. v.*). This is a term not in general use, but is suggested to designate a portico projecting less than the space from one column to another, as the western porticoes to St

Paul's Cathedral, and the portico to the East India House, in London; but that they are recessed also, and therefore may be described as pseudo-prostyle and recessed. The front of Trinity Church in the new road, near the Regent's Park, in London also, presents a mere pseudo-prostyle.

PULVINATED (Lat. *pulvinus*, a cushion or bolster), a term used to express the swelling or bolstering of the frieze which is found in some of the inferior works of the Roman school, and is common in Italian practice. It is used indifferently with pillowed.

PYCNOSTYLE (Gr. πυκνος, dense, and στυλος, a column), columns thickly set. The space or intercolumniation assigned to this term is one diameter and a half. (See EUSTYLE.)

† QUATRE-FOIL, tracery in four foliations or featherings; but applicable only to circular or square panels, and not to arches.

QUOIN (Lat. *ancon*, an elbow or corner, whence the Fr. *coin*), a corner-stone. The stones which are made to project from the regular surface of the walls at the angles of a building are technically called quoins. The front of the Farnese Palace exemplifies them. (See Plate LXX.)

REGULA (Lat.), a rule or square. The short fillet or rectangular block, under the tænia, on the architrave of the Doric entablature, is so called.

† ROSE or CATHERINE-WHEEL WINDOW, the large circular window filled with various tracery, which is common in the upper part of transept fronts in churches and cathedrals. Plate LXXII. fig. 1.

SCOTIA (Gr. σκοτια, shadow or darkness), a concave moulding, most commonly used in bases, which projects a deeper shadow on itself than any other form would possess in an underview position. It is like a reversed ovalo, or rather what the mould of an ovalo would present. Plate LXI.

SCROLL, synonymous with volute. The term scroll is commonly applied to the more ordinary purposes, while volute is generally restricted to the scrolls of the Ionic capital.

SECTION, a drawing showing the internal heights of the various parts of a building. It supposes it to be cut through entirely, so as to exhibit the walls, the heights of the internal doors, and other apertures; the heights of the stories, thicknesses of the floors, &c. It is one of the species of drawings necessary to the exhibition of a Design, *q. v.*

SHAFT. The body or tapering cylindrical mass of a column, from the base below to the capital above, is so called. Plate LXVI. fig. 1.

SILL or SOLE (Lat. *solum*, a threshold, whence the Fr. *seuil*). The horizontal base of a door or window-frame is called its sill, though in practice a technical distinction is made between the inner or wooden base of the window-frame and the stone base on which it rests, the latter being called the sill of the window, and the former that of its frame. This term is not restricted to the bases of apertures; the lower horizontal part of framed partition is called its sill. It is often incorrectly written cill.

SOFFIT (Ital. *soffitta*, a ceiling), the inverted horizontal face of any thing. The horizontal face of an entablature resting on, and lying open between, the columns, is its soffit. The underface of an arch, where its thickness is seen, is its soffit.

SPANDREL. The unoccupied angles, or rather the excluded triangles, of a square, described about a circle, are called spandrels; whence almost any triangular space is designated by the same term.

† SPIRE, the tapering mass which forms the summit of a steeple.

STEEPLE. This term is used in contradistinction to tower, the latter being upright, or nearly so, and terminating almost abruptly, or with pinnacles, and the steeple running to a point with sides converging from the base upwards, or from a certain height only.

STELE (Gr. στηλη, a cippus or small monument). The ornaments on the ridge of a Greek temple, answering to the antefixæ on the summit of the flank entablatures, are thus designated.

STEREOBATE (Gr. στερεος, firm or solid, and βασις, a base or fulciment), a basement. It is sought to make a distinction between this term and Stylobate, *q. v.*, by restricting the latter to its real import, and applying stereobate to a basement in the absence of columns.

STOA (Gr. στοα, a portico). This is the Greek equivalent for the Latin porticus and the Italo-English portico, *q. v.*

STRING or STRING-COURSE, a narrow, vertical-faced, and slightly projecting course in an elevation. If window-sills are made continuous, they form a string-course; but if this course is made thicker or deeper than ordinary window-sills, it becomes a blocking-course.

STYLE (Gr. στυλος, a column). The term style is of very constant use in the composition of architectural names and distinctions, and in those compositions it is not to be understood in its ordinary and almost unlimited application, but in its simple and original meaning,—a column. It is, however, not used in that sense unless in composition; but in its ordinary acceptation it is applied to the varieties of architecture, as the Greek and Roman styles, &c.

STYLOBATE (Gr. στυλος, a column, and βασις, a base or fulciment), a basement to columns. (See STEREOBATE.) Stylobate is synonymous with pedestal, but is applied to a continued and unbroken substructure or basement to columns, while the latter term is confined to insulated supports.

SURBASE (Lat. *super*, whence the Fr. *sur*, above or upon, and *base*, *q. v.*), an upper base. This term is applied to what, in the fittings of a room, is familiarly called the chair-rail. It is also used to designate the cornice of a pedestal or stereobate, and is separated from the base by the dado or die.

SYSTYLE (Gr. συν, together with, and στυλος, a column), columns rather thickly set. An intercolumniation to which two diameters are assigned. (See EUSTYLE.)

† TABERNACLE, a canopied recess or niche. The rich ornamental tracery forming the canopy, &c. to a tabernacle, is called tabernacle-work: it is common in the stalls and screens of cathedrals, and in them is generally open or pierced through.

† TABLET. Projecting mouldings, or moulded strings in the Pointed style, are better described as tablets than as cornices.

TÆNIA (Lat.) a band. (See BAND.)

TERMINAL. Figures of which the upper parts only, or perhaps the head and shoulders alone, are carved, the rest running into a parallelopiped, and sometimes into a diminishing pedestal, with feet indicated below, or even without them, are called terminal figures.

TETRASTOÖN (Gr. τετρα, four, and στοα, a portico). An atrium or rectangular court-yard, having a colonnade or projected orthostyle on every side, is called a tetrastoön.

TETRASTYLE (Gr. τετρα, four, and στυλος, a column), a portico of four columns in front. (See note to HEXASTYLE.)

THOLOBATE (Gr. θολος, a dome or cupola, and βασις, a base or substructure), that on which a dome or cupola rests. This is a term not in general use, but not the less of useful application. What is generally termed the attic above the peristyle and under the cupola of St Paul's, would be correctly designated the tholobate. A tholobate of a different description, and one to which no other name can well be applied, is the circular substructure to the cupola of the London University.

THOLUS or THOLOS (Gr.), a dome or cupola, or any round edifice. This is the only term used by Greek writers that can be supposed to apply to the conical chambers which approach, in internal form, to that of the modern cupola or dome, and is therefore made the Greek equivalent for those terms.

TORUS (Lat.), a protuberance or swelling, a moulding whose form is convex, and generally nearly approaches a semicircle. It is most frequently used in bases, and is for the most part the lowest moulding in a base. Plate LXI.

TOWER, a circular, square, or polygonal structure, with upright or slightly converging sides, running to a height equal to or greater than its diameter or base, and terminating abruptly or in horizontal lines. A tower may be flanked by buttresses whose pinnacles surmount it, and be superimposed by a turret, lantern, or spire.

† TRACERY. The transoms, mullions, and interlaced or flowing continuations of the latter, with their foliations in windows, on doors, panels, and in tabernacle-work, are so called. The ribs on groined ceilings, and almost all eccentric moulded enrichments, come under the same denomination.

TRACHELIUM (Gr. τραχηλος, the neck). In Doric and Ionic columns there is generally a short space intervening the hypotrachelium and the mass of the capital, which may be called the trachelium or neck.

† TRANSOM, the horizontal bar used to divide a mullioned window into heights; the straight and horizontal parts of tracery.

† TREFOIL, tracery in three foliations or featherings.

TRIGLYPH (Gr. τρεις, three, and γλυφη, an incision or channel). The vertically channelled tablets of the Doric frieze are called triglyphs, because of the three angular channels in them, two perfect and one divided; the two chamfered angles or hemiglyphs being reckoned as one. The square sunk spaces between the triglyphs on a frieze are called metopes.

† TURRET, a small tower, or a tower of small base in proportion to its height. Turrets are sometimes placed on the angles of towers; but in the later works of the style they are attached to the angles of structures instead of buttresses, and they run up above their height in lieu of pinnacles.

TYMPANUM, the triangular recessed space inclosed by the cornice which bounds a pediment. The Greeks sometimes placed sculptures representing subjects in connection with the purposes of the edifice, in the tympana of temples.

VAULT, an arched ceiling or roof. A vault is, indeed, a laterally conjoined series of arches. The arch of a bridge is, strictly speaking, a vault. Intersecting vaults are said to be groined. (See GROINING.)

VOLUTE (Lat. *volutum, à volvo*, rolling up or over, convolving). The convolved or spiral ornament which forms the characteristic of the Ionic capital is so called. The common English term is scroll, *q. v.* Volute, scroll, helix, and cauliculus, are used indifferently for the angular horns of the Corinthian capital.

ZOÖPHORUS (Gr. ζωον, an animal, and φερω, to bear). This term is used in the same sense as frieze, and is so called because that part of the entablature is made the receptacle of sculptures which are frequently composed of various animals.

DESCRIPTIONS AND EXPLANATIONS OF THE PLATES.

Plate LIV. The view of the Parthenon in its present state is from an original drawing made on the spot in the year 1821, by Mr W. W. Jenkins. It consequently exhibits the appearance of the splendid ruin before the disasters of the late revolution befell it, as the restored view, under the same aspect, does of the structure in its original state. This is introduced as a frontispiece to the subject, as being an acknowledged master-work of architecture, as well as to enable the reader the better to understand the details of the style of which it is an example, and the composition of that class of structures of which it may be reckoned the principal.

Plate LV. This plate exhibits the varieties of columns and columnar composition which the ancient architecture of various countries presents, and is intended to elucidate their presumed derivation from the single pillar of the earliest records; together with specimens of ancient modes of structure.

Fig. 1 presents an example of the single pillar or stone of memorial, the Monolithon; fig. 2 of the Bilithon, the cromlech of the Celtic nations; fig. 3 of the Trilithon, an example afforded by Stonehenge; and fig. 4 exhibits the immediately succeeding arrangement of pillars, with a continuous entablature.

Fig. 5 shows the flank of the portico of the temple at Amada in Nubia, consisting of square piers or pillars as in fig. 4, and a cylindrical column, which is evidently formed of a similar pillar by working off its angles, the abacus and plinth remaining of the same size and form of which the pillars are.

Fig. 6, pillars with a plain entablature as in fig. 4, from the Rhamesseion at Thebes. The statues placed before the pillars most probably gave rise to the use of such figures to support an entablature, which these have the appearance of doing when seen in front.

Fig. 7, an early Egyptian columnar composition, from Thebes also. In this, as in the example at Amada, the square abacus shows the form and size of the original pillar out of which the singular bulbous column has been sculptured.

Fig. 8, piers of one of the cavern temples of Ellora. These likewise exhibit the tendency to the cylindrical form, and may be assumed as an example of the style of architectural columnar composition at the time they were executed.

Fig. 9, ancient Hindoo columnar piers, in the Mokundra Pass, from Colonel Tod's (unpublished) second volume of the *Annals of Rajast'han*, and by his kind permission. The similarity in character which exists between these and the piers at Ellora in the preceding example, tends to strengthen the remark accompanying them, and affords proof of their contemporaneousness.

Fig. 10, Doric columns and their architrave from the

Descriptions of Plates.

ruins at Corinth, being the earliest known example of their style.

Fig. 11, ancient Persian columns from Persepolis, in front and in profile, the latter showing the mode in which they were probably made to receive an entablature, though a distinguished oriental traveller asserts that the capitals are wrought on the backs in such a manner as to render it improbable that they were ever intended to have any thing placed on them.

Fig. 12, columns in front of the rock sculptures at Mundore, in Marwar, from Colonel Tod's first volume.

Fig. 13, from the ruins of Bheems Chlori, also in the Mokundra pass, from Colonel Tod's unpublished volume. These present another variety of Hindoo columnar composition of early date, though later, it is probable, than the example, fig. 9, *supra*. Figs. 14 and 16 exhibit the modes of structure described in the text at page 414; and fig. 15 is a view of the entrance to the great pyramid at Memphis from Denon and shows the mode of its structure.

Plate LVI. An example of the Egyptian style, sufficiently explained at pp. 410, 432, *et seq.*

Plate LVII. A Greek Doric octastyle, peripteral, and hypæthral temple, with the details of the Parthenon. The plan (fig. 3) is that of the Parthenon (*vide* Plate LIV.) slightly modified, the better to include the class to which it belongs. In the Parthenon the opisthodomus has six columns, as in the pronaos, and not four *in antis* as here laid down: this, however, exhibits the ordinary mode of arrangement. The internal columns are arranged in this plan as they are generally found in other similar structures; and the pedestal for the statue of the divinity is placed in its most probable position.

Fig. 1 shows part of the flank of the temple and the internal composition of the hypæthral cella with its upper range of columns or attic, of the inner chamber or treasury, and of the opisthodomus and posticum: much of this, however, is necessarily taken at a venture, because of the imperfection of the remains of the Grecian edifices.

Fig. 2 exhibits an elevation of the opisthodomus behind the outer range of the portico, not according to the Parthenon, but *in antis*.

Fig. 3 is the plan. In front, on the left-hand side, is the entrance porticus; behind this is the pronaos; within the pronaos is the hypæthral naos or cella, the middle space between the columns being open; the spaces between the columns and the walls on either side are covered; doors (these are not generally laid down to the Parthenon, but are assumed as probable) lead to the inner chamber, said to be the treasury,—this is by some called the opisthodomus, into which it opens, and the opisthodomus stands in the same relation to the posticum that the pronaos does to the porticus.

Fig. 4 is the external order of the Parthenon; fig. 5 the profile of its corona to a larger scale, to show its detail; fig. 6 a half-capital of the same, enlarged also with its annulets larger still.

Fig. 9 is the order of the pronaos; fig. 8 the profile of its corona enlarged; fig. 7 its capital enlarged, with the annulets still larger.

Fig. 10 the antæ cap enlarged; and fig. 12 a half-plan of a column of the Parthenon, showing the contour of its flutes. (*Vide* page 437 *et seq.*)

Plate LVIII. A Greek Doric hexastyle, peripteral, and cleithral temple, with the details of the temple of Theseus at Athens

Fig. 1, front elevation of the temple.

Fig. 2, section behind the outer range of the portico, showing the elevation of the pronaos.

Fig. 3, plan of the temple. The arrangement of the porticus here (to the left) is pseudo-dipteral; a space equal to two intercolumniations and the intervening column being left between the external range and the front of the pronaos,—the projection of the posticum is irregular.

Fig. 4, the external order of the temple of Theseus, with a half-plan of the column; fig. 5, the profile of the corona enlarged; fig. 6, half the capital enlarged; fig. 7, half the capital of the order of the pronaos enlarged also; fig. 9, the antæ, with profiles of the outer and inner entablatures of the pronaos,—this shows also the arrangement of the ceilings.

Fig. 10, enlarged profile of the antæ cap.

Fig. 11, inverted plan of part of the ceilings of the porticus and pronaos, showing the arrangement of the coffers, lacunæ, or cassoons.

Fig. 12, inverted plan of the planceer of the cornice, showing the form and arrangement of the mutules of the external entablature.

Fig. 13 is a plan of the triglyphs of the same on an external angle.

Figs. 8 and 14 are enlarged plans of the flutings of the columns, to show their contours. (*Vide* p. 437 *et seq.*)

Plate LIX. A Greek Ionic hexa-prostyle apteral temple, with details of the temple of Erechtheus at Athens.

Fig. 1, elevation of the portico.

Fig. 2, rear elevation of the temple, showing an attached tetrastyle *in antis*, with windows as they exist in that of the temple of Erechtheus.

Fig. 3, flank elevation. The dotted projection to the right, of the posticum, indicates the amphiprostylar arrangement, which is shown on the plan fig. 4 also, and in the same manner.

Fig. 5, the order of the temple of Erechtheus, except the two lowest steps of the stylobate, which may be easily supplied, to a larger scale, with indications of the carved mouldings, &c.

Figs. 6, 7, and 8 are enlarged profiles of those parts of the entablature which are immediately behind and above them.

Fig. 10, the antæ of the same example, showing the ornament which enriches its necking, and runs along the flank of the edifice; fig. 11, profile of the antæ cap enlarged.

Fig. 12, flank elevation of the capital; all the vertical beads in this are carved. Fig. 13. transverse section of the capital.

Fig. 14, half the longitudinal section of the capital.

Fig. 15, an inverted plan of the capital, showing the arrangement of the flutings.

Fig. 16, an inverted plan of one of the angular capitals. (*Vide* p. 439 *et seq.*)

Fig. 9, the Ionic volute, enlarged to show the mode of striking it, and the contour of its face.

The point at which the volute shall commence, its height, and the diameter of its eye, must be given or assumed; then, "from either end of the whole height of the spiral, cut off the diameter of the given circle (*o* — *o*); divide the remainder into as many equal parts as there are to be revolutions in the spiral (this example is of three revolutions), and divide each of those parts again into four others, so that the remainder or difference between the given circle and the height will be divided into four times the number of revolutions (making in this case twelve); then take half the number of these parts and one part more (seven), together with half the diameter of the eye (*o* — *o*), and set it from the top of the perpendicular downwards, it will give the centre of the volute; take half of one of the parts, and set it from the centre, cutting the per-

pendicular or height of the volute upwards; through that point draw a horizontal line; take half of one of the parts, and set it on each side of the perpendicular, on the horizontal line; from these two points draw diagonals to the centre (refer to the larger diagram to the right of the volute); through the centre draw another line parallel to the horizontal line; through the upper end of each diagonal draw lines parallel to the perpendicular, cutting the horizontal line that passes through the centre into two equal parts; divide each of those parts into as many equal parts as you intend to have revolutions (three). If the volute is intended to be on the left hand (as this is), divide the part next to the centre on that side into two equal parts, but for the right-hand volute on the contrary; from the point of bisection draw two lines parallel to the diagonals downwards; then through each of the divisions on the line which passes through the centre draw lines parallel to the perpendicular, cutting the diagonals at both ends of these perpendicular lines; then join the opposite points of each diagonal by horizontal lines, and the centres will be completed upon each angle of the fret. Begin at the right hand on the upper centre, extend the compass to the height of the perpendicular, and describe the quadrant of a circle to the left hand; then set the compass on the next centre on the left hand, and extend the other leg of the compass to the end of the quadrant, where you left off in the last quadrant; go the same way round to the next centre, and proceed in this manner till you arrive at the last quadrant, which ought to touch the given circle on the upper side upon the perpendicular. Lastly, with one leg of the compasses on the centre of the spiral, and the other foot extended to the distance that the last quadrant cuts the perpendicular, describe a circle, and the spiral will be completed." (Nicholson's *Principles*, &c. vol. ii. p. 23.) To complete the volute as in fig. 5, this process should be repeated for every line indicated at the point of springing in fig. 9, the height of course altering to every one but the eye of the volute, and the point of springing remaining the same.

Plate LX. Fig. 1 the elevation, fig. 2 the plan, and fig. 3 the details, of the order of the Choragic Monument of Lysicrates at Athens. (*Vide* p. 440.)

Fig. 4 presents the elevation, and fig. 5 the plan, of the Caryatic prostyle, which is attached to the flanks of the temple of Erechtheus at Athens.

Fig. 6 shows the detail of the hands and feet of the figure, and of the entablature and stereobate of the same. (*Vide* p. 441.)

Plate LXI. contains Greek and Roman mouldings, with their usual enrichments, all drawn from ancient examples, and detached profiles of them all, together with two examples of Greek and one of Roman ornament. The specimen of Greek ornament on the left hand of the centre is from the neck of the antæ-cap of the tetrastyle portico on the flank of the temple of Erechtheus, generally known as that of Minerva Polias; and the other half of the same is the enrichment of the neck of the antæ of the temple of Erechtheus itself, as shown in Plate LIX. figs. 3 and 10. The Roman specimen of ornament is that of the frieze of the temple of Antoninus and Faustina in Rome. (*Vide* Plate LXII. Ex. 3, and p. 441 and 451.)

Plate LXII. Four Roman examples of the Corinthian order. Ex. 1 is that of the temple of Jupiter Stator in Rome; Ex. 2 is that of the temple of Vesta at Tivoli (*vide* Plate LXIV. fig. 9); Ex. 3 is that of the temple of Antoninus and Faustina in Rome (*vide* Plate LXIV. figs. 6, 7, and 8); and Ex. 4 is the example of the portico of the Pantheon in Rome (*vide* Plate LXIV. figs. 2, 3, 4, and 5). To every example fig. 1 shows the details enlarged, the shafts being cut away; and fig. 2 the elevation of the column and entablature. In every case, also, the distance from the inner surface of the column fig. 2 to the vertical line dividing the examples is one half the intercolumniation at which that example is composed. (*Vide* p. 447 *et seq.*)

Plate LXIII. Examples of the Roman orders. Ex. 1 is the Corinthian of the temple of Mars Ultor; Ex. 2 the Composite of the arch of Titus (*vide* Plate LXIV. fig. 11); Ex. 3 the Ionic of the temple of Fortuna Virilis (*vide* Plate LXIV. fig. 12); and Ex. 4 the Doric of the Theatre of Marcellus, completed from that of the Colosseum. All of these are in Rome. Figs. 1, as in Plate LXII., show the entablatures, capitals, and bases, &c. at an enlarged scale; and figs. 2 the complete elevation of each order, except their stylobates, some of which are not ascertained, and those which are may be obtained from the structures they are referred to in Plate LXIV. (*Vide* p. 447 *et seq.*)

Plate LXIV. Elevations, plans, and sections of sundry Roman edifices, all drawn to the same scale.

Fig. 1 is a longitudinal elevation of the Colosseum. (*Vide* p. 443.)

Fig. 2 is the front elevation, fig. 3 the flank elevation, fig. 4 a section, and fig. 5 the plan, of the Pantheon. The dotted lines before the recess opposite the entrance, fig. 5, show the places the outstanding columns originally occupied. (*Vide* p. 443 and 444.)

Fig. 6 is the front elevation, fig. 7 the plan, and fig. 8 the flank elevation, of the temple of Antoninus and Faustina: of this the front steps and stylobate are restorations. (*Vide* p. 443, and Pl. LXII. Ex. 3.)

Fig. 9 is the plan and elevation of the temple of Vesta at Tivoli; of this the antefixæ and roof are restorations. (*Vide* Pl. LXII. Ex. 2.)

Fig. 10 is the plan and elevation of the triumphal arch of Septimius Severus. (*Vide* p. 443.)

Fig. 11 is a plan and elevation of the arch of Titus. (*Vide ut sup.* and Pl. LXIII. Ex. 2.)

Fig. 12 is a plan and elevation of the temple of Fortuna Virilis. (*Vide* p. 443, and Pl. LXIII. Ex. 3.)

Plate LXV. Plans, sections, elevations, &c. of Roman mansions from Pompeii.

Fig. 1 is a plan of one of the most extensive and most regular of the domestic structures of Pompeii, with its immediate vicinage; it is known as the house of Pansa. The following nomenclature is generally that of Sir William Gell:—1, The entrance or recessed porch; 2, the vestibule; 3, the cavædium or atrium; 4, the compluvium or well for receiving the rain from the roof covering this part of the house (*vide* fig. 2); 5, penaria, or perhaps cubicula; 6, alæ or wings; 7, tablinum or parlour; 8, pinacotheca, or perhaps the library; 9, a passage from the first to the second atrium without passing through the tablinum; 10, cubiculum or bedchamber; 11, peristylium or oicus—the house; 12, impluvium (*vide sup. in* 4, *et* fig. 2); 13, exhedræ or alæ—in these the siesta was taken—they were also used for conversation; 14, cellæ familiaricæ; 15, triclinium—here couches and seats were placed, and company received; 16, lararium or receptacle for the family gods; 17, cubiculum; 18, hall to the gynæceum or women's apartment; 19, the gynæceum—this is believed by some to be a distinct house, and not a part of that of Pansa; 20, porticus or pergula; 21, hortus or garden; 22, a passage from the oicus to the pergula and garden, to avoid the necessity of passing through the triclinium; 23, kitchen; 24, store-room or larder; 25, an open court,

communicating with the street by a doorway. This comprehends the whole of the apartments, &c. appropriated to domestic use—the residence; the other portions of the edifice are distinct from it. 26 is another smaller house; 27, a passage leading to the house of Pansa from the street on the right-hand side; all the places marked 28 are shops open to the street, as shown in the elevation, fig. 3; the rooms marked 29 are storerooms to the shops into which they open; 30 is a bakehouse, in which the mills, &c. are indicated as they exist; 31 is the oven; in the angle of the two adjoining streets on the left hand (32) is the shop of a seller of wine and hot drinks; 33 is a fountain. The walls indicated on the other sides of the streets surrounding the house, &c. of Pansa are the fronts of shops and of some private houses, &c.

Fig. 2 is a section through the house of Pansa from the street to the garden, showing the manner in which it is probable the roofs, &c. were arranged.

Fig. 3 is the probable elevation of the entrance front of this mansion, though the sketch (fig. 4) of part of the same in its present state shows how slight the evidence for it is.

Fig. 5 is an outline of the side of a room, with the ornaments, &c. with which it is decorated. This is an average specimen; many were much plainer, and some were more enriched.

Fig. 6 is the plan of an ordinary sized house in one of the private streets of Pompeii: the uses of the various parts may be generally gathered from those of the similar portions of the house of Pansa. The word SALVE, printed across the threshold, is there wrought in mosaic.

Fig. 7 presents the presumed arrangement of the roofs, &c. of this house in section.

Fig. 8 is the elevation of it towards the street. This absolutely cannot have been better than it appears here, and must have been the ordinary average appearance of the street fronts of Pompeian houses. (*Vide* p. 445 *et seq.*)

Plate LXVI. Fig. 1, an example to show how the term order is applied, and to what parts of it the various technical terms are applied, or are intended to indicate.

Figs. 2, 3, 4, 5, and 6, are the orders of the Italo-Vitruvian school as arranged by Palladio; fig. 2, the Tuscan; fig. 3, the Doric; fig. 4, the Ionic; fig. 5, the Corinthian; and fig. 6, the Composite. (*Vide* p. 451.)

Plate LXVII. Varieties of Italian composition from existing structures in Italy and elsewhere, in the Italian style.

Figs. 1, 2, 3, 4, and 5, are windows of various form and arrangement.

Figs. 6, 7, 8, and 9, are doors of various composition, with plans to show their arrangement and ichnographic projections, &c.

Figs. 10, 11, 12, and 13, are arches and arcades, rusticated and with columns, &c. The plans show their forms and ichnographic projections. (*Vide* p. 452 *et seq.*)

Plate LXVIII. Front elevations alone of the fronts of St Paul's in London and St Peter's in Rome. These two structures exhibit many of the peculiarities of the ecclesiastical architecture of the Italian school. In this plate their comparative magnitude has not been attended to; they are drawn to different scales to bring them more nearly of the same size, so as to render the contrast more effective. (*Vide* p. 426 and 429.)

Plate LXIX. Flank elevations of St Peter's and St Paul's, drawn to the same scale, to show their comparative magnitude, and to enable the reader to judge of their respective merits, as well as to elucidate observations which will be found in the text *passim*. (*Vide* p. 429, &c.)

Plate LXX. Elevations of three esteemed Italian mansions. The merit of this (the principal) elevation of the Farnese Palace is divided between Antonio Sangallo and M. A. Buonaroti. The villa Giulia, near Rome, is esteemed one of the best works of Giacomo Barozzi da Vignola; and the villa Capra near Vicenza, by Palladio, is, by the admirers of his style, considered the most perfect of his works. (*Vide* p. 426, 429, 452, 453, &c.)

Plate LXXI. A series of arches in the Gothic and Pointed styles, from various structures in England. It exhibits the advance of the circular arch from the plainness exhibited in figs. 1 and 2, to the richer and more complicate arrangements of those examples which follow, until the ingrafting and gradual advance of the pointed arch. This first appears in fig. 10. Fig. 12 shows the substitution of the latter for the circular of fig. 9 in a similar composition. Fig. 13 exhibits the pointed arch on Gothic pillars or columns; and fig. 14 the perfected pointed arch with the clustered shafts which become identified with the Pointed style. (*Vide* p. 453 *et seq.*)

Plate LXXII. the elevation of the south transept of Beverley Minster. This affords a perfect and beautiful example of external composition of the first period of Pointed architecture. The presence of the circular arch embracing the pointed arches of the doorway, and composing with others, shows how gradual the advance of the new style was; the upper part of the front showing also how completely it was already systematized when the circular arch was not yet quite discarded. The plan of this front shows the various ichnographic projections, and the arrangement of the clustered shafts of the doors and windows. Fig. 2 is a niche in front of, and fig. 3 a pinnacle to, one of the buttresses of the nave of the same edifice: these are of the second period. Figs. 4, 5, 6, 7, and 8, are windows from various edifices, showing the gradual advance from the plain lancet arch of the Beverley Minster transept to the arch the most elaborately enriched with tracery. Fig. 4 is but a modification of the composition of the doorways of fig. 1, as that is of figs. 9 and 12, Plate LXXI.; and the advance from that may be almost termed natural.

Plate LXXIII. Fig. 1 is a sectional compartment of the nave of Lincoln Cathedral; it exhibits the mode of internal composition peculiar to the style of the first period; tending, however, to the transition, it will be observed, in many particulars, and as a comparison of it with the adjacent example, of the next period, will more clearly show.

Fig. 2 is a similar sectional compartment of the choir of Lincoln Cathedral, exemplifying the internal composition of the second period of the Pointed style; the plans of the shafts to both examples show their forms and arrangement. The subjects of the three last plates are drawn entirely, by his kind permission, from Mr Britton's *Chronological History of Ecclesiastical Architecture.*

Plate LXXIV., the front of York Minster, exemplifies the external composition of the second period, as that of Beverley Minster transept (Plate LXXII. fig. 1) does that of the first period; and the difference will be rendered very clear by comparing them. The upper part of the towers of the front of York Minster, however, it must be remembered (*vide* p. 456), are of the third period, and so is the central tower which appears in the distance between them.

The front of Pisa Cathedral is here introduced in contrast with that of York Minster, to show the striking difference which exists between the real Gothic architecture of Italy and the Pointed style which superseded it so completely, in this country particularly, and to

elucidate our observations to that effect at page 419 *et seq.* The cupola which appears behind and in the distance is surrounded at the base by pointed arches and pinnacles, all of which are evidently of much later date than the Gothic front.

Plate LXXV. Fig. 1 is an elevation of Westminster Hall. It exemplifies the style of external composition of the third period. It was selected because of the variety of matter it contains elucidatory of the period to which it belongs particularly, and of the Pointed style generally. The door, windows, and canopied tabernacles on the second story of the towers are peculiar; the lower tabernacles are more general, and the pinnacles, crockets, corbels, tablets, &c. may also be taken in exemplification of such things in the style generally.

Fig. 2 is a plan of the front, showing the ribs of the groined entrance, the ichnographic projections of the tabernacles, &c.

Fig. 3 is one of the flying buttresses of the flank of the edifice.

Fig. 4 is a spandrel of the entrance porch enlarged.

Fig. 5, crockets of the gable running from the towers to the crowning turret, enlarged.

Fig. 6, part of the head of one of the upper windows of the towers, enlarged.

Fig. 7, a foliated heraldic panel from under the pedestals of the lower tabernacles or niches of the front, enlarged.

Fig. 8, canopies and pinnacles, &c. of the lower tabernacles, enlarged; the buttresses on which they rest are also shown at large in intercepted lengths.

Fig. 9, an enriched foliate pendent of the foregoing example, marked *a*, at a still larger scale.

Fig. 10, one of the pedestals for the reception of statues within the niches or tabernacles, enlarged.

Fig. 11, part of one of the canopies, &c. of the tower tabernacles, enlarged.

Fig. 12, one of the foliate pendents, marked *b*, of the foregoing; and fig. 13 the corbel, marked *c*, of the same, at a still larger scale.

ARCHITRICLINUS, in *Antiquity*, the master or director of a feast, charged with the order and economy of it, the covering and uncovering of the tables, the command of the servants, and the like. The architriclinus was sometimes called *servus tricliniarcha*, and by the Greeks προγευστης, i. e. *prægustator* or *foretaster*. Potter also takes the architriclinus for the same with the symposiarcha.

ARCHIVE, or Archives, a chamber or apartment wherein the records, charters, and other papers and evidences, of a state, house, or community, are preserved, to be consulted occasionally. Thus, we say, the *archives* of a college, of a monastery, &c.

ARCHIVIST, or Archivista, a keeper of an archive. Under the emperors the archivist was an officer of great dignity, held equal to the proconsuls, vested with the quality of a count, styled *clarissimus*, and exempted from all public offices and taxes. Among the ancient Greeks and Persians, the trust was committed to none but men of the first rank; among the Franks, the clergy, being the only men of letters, kept the office among themselves.

ARCHLUTE, or Arciliuto, a long and large lute, having its bass strings lengthened after the manner of the theorbo, and each row doubled, either with a little octave or a unison. It is used by the Italians for playing a thorough bass.

ARCHMARSHAL, the grand marshal of the empire, a dignity belonging to the elector of Saxony.

ARCHONS, in *Grecian History*, were magistrates appointed after the death of Codrus. They were chosen from the most illustrious families till the time of Aristides, who got a law passed, by which it was enacted, that, in electing these magistrates, less regard should be paid to birth than to merit.

The tribunal of the archons was composed of nine officers. The first was properly the *archon*, by whose name the year of his administration was distinguished. The title of the second was *king*, that of the third *polemarchus*; to these were added six *thesmothetæ*. These magistrates, elected by the scrutiny of beans, were obliged to prove before their respective tribes that they had sprung, both in their father's and their mother's side, for three descents, from citizens of Athens. They were likewise to prove that they were attached to the worship of Apollo, the tutelary god of their country; that they had in their house an altar consecrated to Apollo; and that they had been respectfully obedient to their parents,—an important and sacred part of their character, which promised that they would be faithful servants to their country. They were likewise to prove that they had served in a military capacity the number of years which the republic required of every citizen; and this qualification gave the state experienced officers, for they were not allowed to quit the army till they were 40 years old. Their fortune, too, of which they were to inform those before whom they were examined, was a warrant for their fidelity.

After the commissioners who were appointed to inquire into their character and other requisites had made a report of them, they were then to swear that they would maintain the laws, which obligation if they neglected, they engaged to send to Delphi a statue of the weight of their bodies. According to a law of Solon, if an archon got drunk, he was condemned to pay a heavy fine, and sometimes even punished with death. Such magistrates as the Athenian archons were well entitled to respect. Hence it was eternal infamy to insult them; and hence Demosthenes observed, that to treat the thesmothetæ with disrespect, was to show disrespect to the public.

Another qualification indispensably required of the second officer of this tribunal, who was called the *king*, was, that he had married the daughter of an Athenian citizen, and that he had espoused her a virgin. This was exacted of him, says Demosthenes, because part of his duty was to sacrifice to the gods jointly with his wife, who, instead of appeasing, would have irritated them, if she had not possessed both these honours.

When any obscurity occurred in the laws relative to religion and the worship of the gods, the interpretation was submitted to the tribunal of the archons. They were the principal officers, not only in civil, but likewise in sacred matters, and especially in the mysteries of Bacchus. The archons, however, who were surnamed *eponymi*, were chiefly employed in civil affairs; yet they presided at the great feasts, and held the first rank there. Hence they are sometimes styled *priests*.

Archon is also applied by some authors to divers officers, both civil and religious, under the eastern or Greek empire.

ARCHONTICI, in *Ecclesiastical History*, a branch of Valentinians who maintained that the world was not created by God, but by angels called *Archontes*.

ARCHPRIEST, or Archpresbyter, a priest or presby-

ter established in some dioceses, with a pre-eminence over the rest. Anciently the archpriest was the first person after the bishop: he was seated next to him in the church, and in his absence acted as his vicar in all spiritual matters. In the sixth century there were several archpriests in the same diocese, from which period some believe them to have been called *deans*. In the ninth century there were two kinds of cures or parishes; the smaller governed by simple priests, and the baptismal churches by archpriests, who, besides the immediate concern of the cure, had the inspection of the other inferior priests, and gave an account of them to the bishop, who governed the chief or cathedral church in person. Archpresbyters still exist in the Greek church, who are invested with most of the functions and privileges of chorepiscopi or rural deans.

ARCHYTAS of Tarentum was a Pythagorean philosopher, well skilled in mathematics and geography. He lived in the time of Plato, and, according to report, interposed his influence with Dionysius the tyrant, in order to save the life of that philosopher. According to this date, it would appear that Jamblichus is mistaken when he asserts that he was a hearer of Pythagoras; and the testimony of a writer mentioned by Photius would seem more worthy of credit, that he was the eighth successive preceptor of the Pythagorean school. So eminent were his military talents, that, in opposition to an express law of his country, that no man should be chosen more than once the general of its armies, he was elevated to that station no less than seven times. He taught that there is nothing so destructive to man as pleasure; that virtue is to be pursued for its own merit, and that every extreme is incompatible with it. Aristotle, according to some, was indebted to Archytas for his general heads of arrangement entitled his *Ten Categories*. By discovering the duplication of the cube by means of the conic sections, and the method of finding two mean proportionals between two given lines, he displayed his great knowledge in mathematics. Archytas is reported to have invented several curious hydraulic machines, and his genius is likewise honoured with the invention of the screw and crane. He perished in a shipwreck, and his body was found on the Apulian coast,—an occurrence commemorated in one of Horace's Odes. A treatise on the Categories, bearing his name, was published by J. Camerarius at Leipsic, in 8vo, in 1564. Certain Fragments, also ascribed to him, were published by J. Gramm at Copenhagen, in 4to, in 1707.

ARCIS-SUR-AUBE, an arrondissement in the department of the Aube, in France, extending over 499 square miles, or 319,360 acres, and containing four cantons, 90 communes, and 33,260 inhabitants.—The capital of the arrondissement is of the same name, containing 366 houses, and 2500 inhabitants, who carry on some manufactures of cotton and of hosiery, and have a considerable trade in corn by means of the river Aube, on whose left bank it is situated. Long. 4. 14. E. Lat. 48. 30. N.

ARCO, a strong town and castle in the Trentin, belonging to the house of Austria. It stands on the river Sarca, near the northern extremity of the lake Garda. Long. 10. 48. E. Lat. 45. 52. N.

ARCON, J. C. E. Le Michaud d', a French engineer and military writer of eminence, and memorable as the inventor of the floating batteries employed against Gibraltar, was born at Pontarlier in the year 1733. He was originally destined for the church; but, instead of employing himself in the studies suited to that profession, he became wholly engrossed with plans of fortifications, and was at length admitted, with the consent of his parents, into the corps of engineers. He distinguished himself at several sieges during the seven years' war; and had acquired so much reputation by his professional services and by his writings, that he was specially employed to assist in the last grand effort made by France and Spain for the reduction of Gibraltar in 1782. It was about this period that he projected the famous floating batteries; an invention which inspired the combined armies with the greatest hopes of success, and which at first occasioned no small degree of alarm in the British garrison. "The battering ships," says Drinkwater, in his interesting account of this memorable siege, "were found to be no less formidable than they had been represented. Our heaviest shells often rebounded from their tops, whilst the 32 pound shot seemed incapable of making any visible impression upon their hulls. Frequently we flattered ourselves they were on fire; but no sooner did the smoke appear than, with the most persevering intrepidity, men were observed applying water, from their engines within, to those places whence the smoke issued." Of the ultimate fate of these expensive and formidable engines of attack all British readers must be sufficiently informed. Not one of the whole ten escaped destruction from the bombs and red-hot balls poured upon them from the garrison. M. d'Arçon, however, published a memoir to show that his batteries were wilfully exposed to destruction through the envy and jealousy which the contrivance had excited among the Spaniards; and this statement seems to have obtained the general concurrence of his countrymen. But projectors do not readily admit any inadequacy in their schemes; nor will a vain-glorious people, who have been foiled in war, ever ascribe their disgrace to the superior skill or constancy of their enemy.

M. d'Arçon appeared in the capacity of a general in the first years of the Revolution; and, in particular, was employed in the invasion of Holland, where, in 1793, he besieged and took several fortified places. He soon afterwards withdrew or was driven from public life, and remained in retirement till 1799, when he was made a member of the Conservative Senate by Buonaparte. He died the following year, aged sixty-seven. He was a member of the Institute, and author of the following works:—1, Réflexions d'un Ingénieur, en réponse à un Tacticien, 1773, 12mo; 2, Correspondance sur l'Art de la Guerre, entre un Colonel de Dragons et un Capitaine d'Infanterie, 1774, 8vo; 3, Défense d'un Système de Guerre Nationale, &c. 1779, 8vo; 4, Mémoires pour servir à l'Histoire du Siège de Gibraltar, 1783, 8vo; 5, Considérations sur l'Influence du Génie de Vauban dans la Balance des Forces de l'Etat, 1786, 8vo; 6, Examen détaillé de l'importante Question de l'Utilité des Places Fortes et Retranchements, 1789, 8vo; 7, De la Force Militaire Considérée dans ses Rapports Conservateurs, 1790, 8vo; 8, Considérations Militaires et Politiques sur les Fortifications, 1795, 8vo. This work was published at the expense of the government, and contains a sort of digest of all his observations and opinions on military subjects.—See *Biographie Moderne*, tome i., and *Biographie Universelle*, tome ii.

ARCONA, a strong town situated on the island of Rugen in the Baltic. It stood on a high promontory, with the east, north, and south sides defended by steep and lofty precipices, and the west by a wall 50 feet high, proportionably thick, and secured by a deep and broad ditch. It was, however, taken and ruined in 1168, by Valdemar, king of Denmark.

ARCOS de la Frontera, a Spanish town in Andalusia, between Ronda and Santa Maria. It is situated on the banks of the river Guadalette, celebrated for that decisive battle of three days' continuance, by the event of which the crown of the Gothic kings of Spain was transferred to the Arabian invaders. It contains two parish churches, seven monasteries, 2500 houses, and 12,000 inhabitants. Long. 5. 55. W. Lat. 36. 39. N.

ARCOT, a large district of Hindostan, under the presidency of Madras, to which it was transferred in 1801, being previously an independent state. It is now divided into north and south, and, since 1809, when an improved mode of management was introduced, the condition of the country has been greatly ameliorated under the British administration. The limits of northern Arcot, though they are not very exactly defined, may be stated to be, on the north Cuddapah and Nellore; southern Arcot on the south; the district of Chingleput and the sea on the east; and Balaghaut of Cuddapah on the west. It is watered by the river Palar, and the chief towns are Arcot, Wallajanagur, Vellore, and Tripetty. Southern Arcot has the northern division of Arcot for its boundary on the north; Tanjore and Trichinopoly on the south; on the east the Chingleput district and the sea; and Salem and the Balaghaut Carnatic on the west. The principal trading ports are Cudalore and Porto Novo. The population of both these districts amounted, according to returns received in 1822, to 1,347,312 persons.

Arcot, a city of Hindostan, and formerly the capital of the Carnatic, situated on the south side of the river Palar, which has a channel half a mile in breadth; but, except during the season of the rains, is nearly dry. The town is extensive, and is built round a large fort, of which the principal defences were destroyed more than twenty years ago, and its area is now under cultivation. The town is defended from the inundations of the river when it is swollen by the rains by the remaining ramparts of the fort, which on that side are kept in good repair. It is inclosed by walls, and contains the former palace of the nabobs of Arcot, which, with the exception of a gateway still entire, is in ruins; a handsome Mahometan mosque, and four or five other well-built religious edifices of the Mahometans, and numerous tombs. Arcot is supposed to have been the capital of the Soræ, or the Soramundalum of Ptolemy, whence by an easy derivation Coromandel; but the present town is entirely of modern date. The Mogul armies, after they had captured Gingee, found the situation so unhealthy that they were forced to remove to the plains of Arcot, and began to build the present town about the year 1716. The nabob of Arcot, Anwanud Deen, being killed in battle in 1749, the place was taken by his competitor, who was supported by the French. In 1751 it was retaken by Colonel Clive with 500 troops, from a garrison of 1100 men; and here that gallant soldier maintained himself for fifty days against the attacks of the French and their Indian allies, who were finally compelled to raise the siege. It was afterwards taken by the French, but was recaptured in 1760 by Colonel Coote, after the battle of Wandewash. Hyder Ali gained possession of it for a time after he had defeated the British under Colonel Baillie in 1780. Travelling distance, 217 miles E. of Seringapatam, 73 W. of Madras, 1070 S. W. of Calcutta, and 1277 S. of Delhi. Long. 79. 22. E. Lat. 12. 52. N.

ARCTIC, in *Astronomy*, an epithet given to the north pole, or the pole raised above our horizon. It is called the *arctic pole*, on occasion of the constellation of the little bear, in Greek called αρκτος, the last star in the tail of which nearly points out the north pole.

Arctic Circle is a lesser circle of the sphere, parallel to the equator, and 23° 30′ distant from the north pole; from whence its name. This, and its opposite, the *antarctic*, are called the two *polar circles*, and may be conceived to be described by the motion of the poles of the ecliptic round the poles of the equator or of the world.

ARCTURUS, in *Astronomy*, a fixed star of the first magnitude, in the constellation Arctophylax, or Bootes. The word is formed of αρκτος, *bear*, and ουρα, *tail*, *bear's tail*, as being very near it.

ARCY, Patrick d', member of the Academy of Sciences of Paris, a general officer in the French army, Chevalier of the order of St Louis, &c. was born in Ireland in 1725. His parents, in consequence of their attachment to the house of Stuart, left Ireland, and settled in France. He studied mathematics with distinguished success under Clairaut the elder, and had for his fellow-student the celebrated Clairaut the son. He obtained a commission in the French army; and, in 1746, was embarked in the expedition which was intended to make a descent into Scotland. He was made prisoner, and was treated like other prisoners of war, no notice being taken of his having been born a British subject. He continued attached to the house of Stuart during the whole of his life.

In 1760 he published his *Essay on Artillery*. To estimate the force of the explosion of gunpowder he employed a cannon suspended so that the arc of vibration described by it on its being fired was a measure of the force of explosion. To measure the initial velocity of a projectile, he used Robins's machine. Robins showed that when the velocity of a projectile is great, the resistance opposed by the air is not in proportion to the square of the velocity, as is the case when the velocity is small. D'Arcy made experiments with a view of ascertaining this law, but without success. His work contains an account of experiments made by him to determine the most advantageous length of cannon. He published a paper on hydraulic machines in 1754, where he treats of the maximum of effect of water-wheels. He also published a paper concerning the duration of the impression of light on the retina. He found that the revolution of a luminous point must be rapid, so as to be performed in $\frac{8}{60}$ of a second at the least, in order to produce the appearance of a continued luminous circle.

He was of a handsome figure, and passed much of his time in the gay world. A short time before his death he married a young lady, his niece, and took the title of Count. Although attached to the house of Stuart, and therefore inimical to the English government, yet he admired the national character of the English, and was attentive to English travellers. He died in 1779, and was succeeded at the academy by the Abbé Bossut.

ARDAMON, or Ardama, in *Antiquity*, a vessel of water placed at the door of a person deceased till the time of burial, as a token that the family was in mourning, and to serve to sprinkle and purify persons as they came out of the house.

ARDATOW, a circle of the Russian government of Nishegorod, between long. 41. 37. and 43. 24. E. and lat. 54. 57. and 55. 44. N. It is watered by the rivers Tescha, Lemela, and some smaller streams, consists of gentle hills, and is abundantly wooded. The arable land is small, but it produces much cattle, flax, and wood; and the chief iron-works of the province are within this circle, but much of the ore is brought from Valdimir. The inhabitants are about 95,000, of whom 7798 are slaves of the crown, and 17,659 belong to individual nobles. It contains one city and ten parishes with churches. The capital of the circle is of the same name. It is situated on the river Lemela, has one church, 152 houses, and 906 inhabitants. It is in long. 42. 55. E. and lat. 55. 10. N.

ARDEBIL, or Ardebeel, a town of Persia, in the province of Azerbijan, on a river which runs into the Aras or Araxes. It is situated on the southern side of the desert plain of Ardebil, which is 60 miles in length by 40 in breadth. The town contains about 500 or 600 families, and appears to have been built from some former city. It is surrounded by a ruinous wall of mud, flanked with towers in a like state of decay. It has a fort, which is a regular square, with bastions at the corners, fortified ac-

cording to the European fashion. The only objects of interest are the tombs of Sheik Suffee, the ancestor of the Suffanean kings, and his descendants. It is still held in veneration as having been the residence of that royal prince.

ARDELAN, a province of Persia, which forms the eastern division of Kurdistan. It extends in length 200 miles from the little river Sharook to the Turkish district of Zohaub, and it is nearly 160 miles in breadth. It is divided from the plain of Hamadan by a small range of hills, and its western boundary is 100 miles beyond Senna, the capital, which is situated in long. 40. E. and lat. 35. 12. N. 60 miles from Hamadan. From the Sharook, which separates the province from Azerbijan, to Senna, the country presents either a succession of hills clustered together, and heaped upon each other, or great table-lands covered with the flocks and tents of wandering shepherds, who pass the summer here, and migrate in the winter to the vicinity of Bagdad. The soil in the valleys or glens, which are narrow strips at the foot of the mountains, is fertile, and yields abundance of wheat and barley. The oil plant is everywhere cultivated, and also tobacco, though in small quantities. The deep valley in which the capital is situated is well cultivated, and interspersed with orchards of fruit-trees. The mountains to the west are covered with forests of oak, which produce fine timber, and abundance of gall-nuts, which are exported to India, while the oak is floated down the Tab into the Tigris. The inhabitants, and other pastoral and rude tribes, make little use of the natural advantages of the country, being addicted to war, cruelty, and rapine. There is another tribe of shepherds named Gheshkee, who are most expert and daring robbers. These tribes are under the government of a powerful chief, who pays an annual tribute to Persia, but is in all other respects independent. He rules over his vassals with the most absolute power, but is said to govern rather like a patriarch than a tyrant.

ARDEN, the common name of forests among the Celtæ. It is written *Arduen* by Cæsar and Tacitus in speaking of the forest in Gaul. *Arduen*, *Ardven*, or *Arden*, then, means a considerable wood.

ARDENBURG, a town of the Netherlands, in Dutch Flanders, and formerly the most considerable in that country; but it has been dismantled by the Dutch. Long. 3. 30. E. Lat. 51. 16. N.

ARDENNE, a forest in France, formerly of vast extent. At present it extends from Thionville, near the country of Liege, to Doncherry and Sedan, on the confines of Champagne.

ARDENNES, a department of France, formed out of a part of the ancient forest of the same name. It is bounded by the Netherlands and the department of the Meuse on the north and east, by the department of the Aine on the west, and that of the Marne on the south. The extent is 1,142,720 acres, and the population 258,896. It is divided into five arrondissements. It produces wood from its forests, breeds much cattle, grows some medium wine, and obtains coals, iron, and slate.

ARDENTES, among middle-age writers, an appellation given to those afflicted with the ignis sacer, or erysipelas. They were so called from their appearing as if scorched or burned with the disease. The abbey of St Genevieve at Paris is said to have received the name of *Domus Ardentium* because great numbers were cured of that distemper at the shrine of this saint in the reign of Louis VI.

ARDES, a town of France, in Lower Auvergne, and now in the department of Puy de Dôme. It serves as a mart for the commodities and trade between Upper and Lower Auvergne. Long. 3. 10. E. Lat. 45. 22. N.

ARDFERT, a town of Ireland, in the county of Kerry, of which it was formerly the capital, though it is now a ruinous and decayed village. It had at one time a university, and was a bishop's see; but it is now united to that of Limerick. Here are several religious edifices; and a pillar tower, which stood near the cathedral, and was one of the loftiest and finest in the kingdom. It fell in 1771. Four miles N. W. of Tralee.

ARDOYE, a market-town, with 6150 inhabitants, on the river Drybeke, in the arrondissement of Bruges and province of West Flanders, in the kingdom of the Netherlands.

ARDRAH, a considerable town, capital of a territory of the same name, situated on the Slave Coast of Africa. It lies about twenty-five miles inland, on the interior shore of a lake nearly 60 miles in length and from 3 to 12 in breadth, agreeably diversified with numerous islands. The surrounding country is fertile and beautiful, abounding in the tropical products of sugar-cane, cotton, maize, and fine indigo. Ardrah, with all this coast, was in 1724 conquered and dreadfully desolated by the king of Dahomey, to whom, in 1772, it still continued subject, and had only imperfectly regained its prosperity. Since that time the preponderance acquired by the kingdom of Eyeo or Yarriba, lately visited by Clapperton, has rescued it from this yoke; and it forms now nearly an independent republic, under the protection of that state. The internal constitution is nearly democratic, though there are some great merchants who possess considerable influence. The people are industrious, manufacturing cloth both from cotton and grass, and working with some skill in iron and leather. The population is reckoned by Adams at nearly 10,000, among whom, to his surprise, he found a number of Mahometans who had come from Houssa, with which there is a pretty direct communication through Eyeo. They have introduced the use of horses as domestic animals, and of milk as an article of diet, neither of which is known on any other part of the coast. The market, held every sixth day, presents a crowded and busy scene, at which are exhibited the manufactures of Europe, particularly of Manchester and Silesia, mingled with the calicoes of India, and with cloths and dyed leather brought from the interior countries; also tobacco from Brazil, coral, beads, &c. Several of the merchants possess considerable wealth, and imitate in a good measure the European dress, furniture, and mode of living. Long. 3. 42. E. Lat. 6. 26. N.

ARDRES, a town of France, in Lower Picardy. Here was an interview between Francis I. and Henry VIII. king of England in 1520. It is eight miles south of Calais. Long. 2. 0. E. Lat. 50. 35. N.

ARDROSSAN, a sea-port and parish of Scotland, in the county of Ayr, which has been of late years laid out on a regular plan, and with commodious buildings, and is now a sea-bathing resort. It has a safe and spacious harbour. Population of the parish 3105.

ARDSISCH, or Argisch, a circle in the province of Wallachia, now comprehending within it the circle of Lowwishta. It lies to the south of the Carpathian Mountains, through which, by the pass of Rothe Thurm, there is a way into Hungary. The circle contains two cities, two market-towns, and 202 villages and hamlets. The chief city, Ardisch, which was once the seat of the governors of the country, is fast decaying; but it still contains six churches, a large and beautiful monastery, and the ruins of the ancient palace of the sovereigns.

AREA, in general, denotes any plain surface whereon we walk, &c. The word is Latin, importing more properly a threshing floor; and is derived from *arere* to be dry.

Area, in *Architecture*, denotes the space or site of ground on which an edifice stands. It is also used for inner courts and other inclosed spaces.

AREA, in *Geometry*, denotes the superficial content of any figure. Thus, if a figure, *e. g.* a field, be in form of a square, and its side be 40 feet long, its area is said to be 1600 square feet; or it contains 1600 little squares, each a foot every way.

AREBO, a considerable town of Benin, in Africa, on the river Formosa. Both the English and Dutch once held factories there, which they have now abandoned. Long. 5. 8. W. Lat. 5. 58. N.

AREMBERG, a small town of Germany, in the circle of Westphalia, defended by a castle. It is the capital of a county of the same name, and was erected into a principality by the emperor Maximilian II. in favour of John de Ligne, lord of Barbazon, who took the name of *Aremberg*. It is seated on the river Aer. Long. 6. 44. E. Lat. 50. 27. N.

ARENA, in *Roman Antiquity*, a place where the gladiators fought; so called from its being always strewed with sand to conceal from the view of the people the blood spilt in the combat. Nero is said to have strewed the arena with gold dust.

ARENARII, in *Antiquity*, gladiators who combated with beasts in the arena or amphitheatre. The arenarii were slaves of the lowest rank; so that, though manumitted, they were not capable of being Roman citizens. They were the same with what were otherwise called *Bestiarii*.

ARENARIUM, in ecclesiastical writers, denotes a cemetery or burying ground. The arenaria were properly a kind of pits or holes under ground, in which the ancient Christians not only buried their dead, but held their religious assemblies in times of persecution.

ARENSBERG, one of the governments (*regierungsbezirk*) into which the Prussian province of Westphalia is divided. It is subdivided into 14 portions called circles (*kreis*). It comprises within its limits part of the ancient duchy of Westphalia, the county of Mark, with Dortmund, the city of Lippstadt, the principality of Siegen, and the lordships of Witgenstein-Besleburg, Witgenstein-Witgenstein, and Hohen-Limburg. It extends over 3060 square miles, or 1,958,400 acres. The cities and towns are 74, the villages 1119. The inhabitants amounted in the year 1817 to 380,182, of whom 202,766 were Protestants, 178,826 Catholics, 3489 Jews, and 101 Menonites.

ARENSBERG, one of the circles into which the government of the same name is divided. It contains 32,352 inhabitants, in six cities, 12 towns, and 105 villages. In the northern part it is mountainous and woody; the rest of the circle has a loamy but stony soil, which produces rye, potatoes, and flax. It has little trade except in wood and wood-wares; but the females occupy themselves in spinning.

ARENSBERG, the capital of the government and circle of the same name. It was formerly a flourishing place, but has much declined. It is almost surrounded by the river Ruhr. It has 245 houses and 2623 inhabitants.

ARENSBURG, a circle in the Russian government of Livonia, comprehending the islands of Oesel, Moen, Ruhna, and several smaller ones, in the Gulf of Riga in the Baltic Sea. The surface of these islands is 2176 square miles, and, in spite of a rigorous climate, they are moderately fertile, producing rye, buck-wheat, flax, hemp, tobacco, potatoes, turnips, and other vegetables, where the land is manured with sea-weed, which abounds on the shores. The cattle, both for the dairy and the butcher, are good; and there are some sheep, which yield fine wool. The island of Arensburg is well watered, though it has no river, but several brooks and lakes. The inhabitants in 1792 were 34,256, and we have no later notices of these islands. The island of Arensburg alone is far more populous than all the others, and contains one city, 12 church parishes, and 161 farms. The people speak a peculiar dialect of German, and adhere to the Lutheran profession of religion. The capital of the circle is a city of the same name, on the south-east side of the island of Oesel, in a small bay, visited yearly by about 40 vessels of easy burden. It is ill built, with wooden houses, has 2 churches, 1 public school, 194 dwellings, and 1390 inhabitants. It is in long. 22. 22. 15. E. and lat. 58. 15. 45. N.

ARENSWALDE, a circle in the government of Frankfort, and province of Pomerania, in Prussia. Its extent is 472 square miles, or 302,080 acres, and the population amounted in 1817 to 20,705 persons. It has a number of small lakes, which yield good fish. The corn land produces some rye, and the inhabitants are also employed in rearing and feeding cattle; but their means of subsistence is chiefly derived from the extensive woods with which it abounds.

ARENSWALDE, the chief town of the circle of the same name in Prussia. It contains 474 houses, and 2875 inhabitants, who find some employment in weaving cloth, and some in distilleries.

ARENZ DE MAR, a town of Spain, on the sea-shore, in the province of Catalonia. It contains 3500 inhabitants, and has manufactories for cotton, silk, woollen goods, and stockings. There is a yard for building ships, and a forge for casting anchors.

AREOLA, among anatomists, the coloured circle surrounding the nipple of the breast.

AREOPAGUS, a sovereign tribunal at Athens, famous for the justice and impartiality of its decrees, to which the gods themselves are said to have submitted their differences. See the article ATTICA.

ARETÆUS of Cappadocia, a Greek physician of the sect of the Pneumatists, who, according to some, lived in the reign of Augustus; according to others, under Trajan or Adrian. He wrote several treatises, in the Ionian dialect, on acute diseases and other medicinal subjects, some of which are still extant. The best edition of his works is that of Boerhaave, in Greek and Latin, with notes, printed in 1731; that printed at Oxford in 1723, in folio, is also much esteemed.

ARETHUSA, the daughter of Nereus and Doris, and the companion of Diana, who changed her into a fountain to deliver her from the pursuit of her lover Alpheus.

ARETHUSA, a celebrated fountain near the city of Syracuse, in Sicily, famous for the quantity of its waters, and the number of fishes it contained. Many fables were invented by the ancients concerning this fountain. They had also a notion that the river Alpheus ran under or through the waters of the sea, without mixing with them, from Peloponnesus to Sicily. Mr Brydone informs us that it still continues to send forth an immense quantity of water, rising at once to the size of a river, but is entirely abandoned by the fishes it formerly contained in such plenty. Mr Swinburne describes this once famous fountain as a large pool of water near the quay, defended from the sea by a wall, and almost hidden by houses on every other side. The water is not salt, but brackish, and fit for no purpose but washing linen. "Such," says he, "is the celebrated fountain of Arethusa, whose soft, poetical name is known to every reader."

ARETIN, GUIDO, famous for his musical improvements, lived in the 13th century. He was a native of Arezzo, a city in Tuscany; and having been taught the practice of music in his youth, and being probably retained as a chorister in the service of the Benedictine monastery founded in that city, he became a monk professed, and a brother of the order of St Benedict.

In this retirement he seems to have devoted himself to the study of music, particularly the system of the ancients,

and, above all, to reform their method of notation. The difficulties that attended the instruction of youth in the church offices were so great, that, as he himself says, ten years were generally consumed barely in acquiring the knowledge of the plain song; and this consideration induced him to labour after some amendment,—some method that might facilitate instruction, and enable those employed in the choral office to perform the duties of it in a correct and decent manner. Were we to credit those legendary accounts that are extant in old monkish manuscripts, we should believe he was assisted in his pious intention by immediate communications from heaven. Some speak of the invention of the syllables as the effect of inspiration; and Guido himself seems to have been of the same opinion, by his saying it was revealed to him by the Lord, or, as some interpret his words, in a dream. Graver historians say, that being at vespers in the chapel of his monastery, it happened that one of the offices appointed for that day was the hymn to St John,—

UT queant laxis *REsonare fibris*
MIra gestorum *FAmuli tuorum*
SOLve pollutis *LAbiis reatum,*
Sancte Joannes.

During the performance of the hymn, he remarked the iteration of the words, and the frequent returns of UT, RE, MI, FA, SOL, LA. He observed likewise a dissimilarity between the closeness of the syllable MI and broad open sound of FA, which, he thought, could not fail to impress upon the mind a lasting idea of their congruity; and immediately conceived a thought of applying these six syllables to perfect an improvement either then actually made by him, or under consideration, viz. that of converting the ancient tetrachords into hexachords.

Struck with the discovery, he retired to his study, and having perfected his system, began to introduce it into practice. The persons to whom he communicated it were the brethren of his own monastery, from whom it met with but a cold reception, which he ascribed to envy. However, his interest with the abbot, and his employment in the chapel, gave him an opportunity of trying the efficacy of his method on the boys who were training up for the choral service, and it exceeded the most sanguine expectation. "To the admiration of all," says Cardinal Baronius, "a boy thereby learnt, in a few months, what no man, though of great ingenuity, could before that attain in several years."

The fame of Guido's invention soon spread abroad, and his method of instruction was adopted by the clergy of other countries. We are told by Kircher, that Hermannus, bishop of Hamburg, and Elviricus, bishop of Osnaburg, made use of it; and by the authors of the *Histoire Littéraire de la France*, that it was received in that country, and taught in all the monasteries in the kingdom. It is certain that the reputation of his great skill in music had excited in the pope a desire to see and converse with him; of which, and of his going to Rome for that purpose, and the reception he met with from the pontiff, he himself has given a circumstantial account in the epistle hereafter mentioned.

It seems that John XX., or, as some writers compute, the nineteenth pope of that name, having heard of the fame of Guido's school, and conceiving a desire to see him, sent three messengers to invite him to Rome. Upon their arrival, it was resolved by the brethren of the monastery that he should go thither attended by Grimaldo the abbot, and Peter the chief of the canons of the church of Arezzo. Arriving at Rome, he was presented to the holy father, and by him received with great kindness. The pope had several conversations with him, in all which he interrogated him as to his knowledge in music; and upon sight of an antiphonary which Guido had brought with him, marked with the syllables agreeable to his new invention, the pope looked upon it as a kind of prodigy, and ruminating on the doctrines delivered by Guido, would not stir from his seat till he had learned perfectly to sing off a verse; upon which he declared that he could not have believed the efficacy of the method, if he had not been convinced by the experiment he had himself made of it. The pope would have detained him at Rome; but labouring under a bodily disorder, and fearing an injury to his health from the air of the place, and the heats of the summer, which was then approaching, Guido left that city upon a promise to revisit it, and explain to his holiness the principles of his new system. On his return homewards he made a visit to the abbot of Pomposa, a town in the duchy of Ferrara, who was very earnest to have Guido settle in the monastery of that place; to which invitation, it seems, he yielded, being, as he says, desirous of rendering so great a monastery still more famous by his studies there.

Here it was that he composed a tract on music, entitled *Micrologus*, i. e. a short discourse, which he dedicated to Theobald, bishop of Arezzo; and finished, as he himself at the end of it tells us, under the pontificate of John XX., and in the 34th year of his age. Vossius speaks also of another musical treatise written by him, and dedicated to the same person.

Most of the authors who have taken occasion to mention Guido, speak of the Micrologus as containing the sum of his doctrine; but it is in a small tract, entitled *Argumentum novi Cantus inveniendi*, that his declaration of his use of the syllables, with their several mutations, and in short his whole doctrine of solmisation, is to be found. This tract makes part of an epistle to a very dear and intimate friend of Guido, whom he addresses thus, "Beatissimo atque dulcissimo fratri Michaeli," at whose request the tract itself seems to have been composed.

Whether Guido was the author of any other tracts is not easy to determine. It nowhere appears that any of his works were ever printed, except that Baronius, in his *Annales Ecclesiastici*, tom. xi. p. 73, has given at length the epistle from him to his friend Michael of Pomposa, and that to Theobald, bishop of Arezzo, prefixed to the Micrologus; and yet the writers on music speak of the Micrologus as of a book in the hands of every one. Martini cites several manuscripts of Guido; namely, two in the Ambrosian library at Milan, the one written about the twelfth century, the other less ancient; another among the archives of the chapter of Pistoja, a city in Tuscany; and a third in the Medico-Laurenziano library at Florence, of the fifteenth century: these are clearly the Micrologus. Of the epistle to Michael of Pomposa, together with the *Argumentum novi Cantus inveniendi*, he mentions only one, which, he says, is somewhere at Ratisbon. Of the several tracts above mentioned, the last excepted, a manuscript is extant in the library of Baliol college in Oxford.

ARETIN, *Leonard*, one of the most learned men of the fifteenth century, was secretary to the republic of Florence, and translated from the Greek into Latin some of the Lives of Plutarch, and Aristotle's Ethics. He also composed three books of the Punic war, that may serve as a supplement to those wanting in Livy; the history of the transactions in Italy during his time; that of ancient Greece; that of the Goths; that of the republic of Florence; and many other books. He died in 1443, aged 74.

ARETIN, *Francis*, a man of great reading, and well acquainted with the Greek language. He translated into Latin the Commentaries of St Chrysostom upon St John, and about 20 homilies of the same father; he also trans-

lated the Letters of Phalaris into Latin, and wrote a treatise *De Balneis Puteolanis*. He studied at Sienna about the year 1443, and afterwards taught law there with such reputation that they called him the *Prince of Subtleties*. He taught also in the university of Pisa, and in that of Ferrara.

Aretin, *Peter*, a native of Arezzo, who lived in the 16th century. He was famous for his satirical writings; and was so bold as to carry his invectives even against sovereigns, and from thence got the title of the *Scourge of Princes*. Francis I., the emperor Charles V., most of the princes of Italy, several cardinals, and many noblemen, courted his friendship by presents, either because they liked his compositions, or perhaps from an apprehension of falling under the lash of his satire. Aretin became so insolent, that he is said to have got a medal struck, on one side of which he is represented, with these words, *Il divino Aretino;* and on the reverse, sitting upon a throne, receiving the presents of princes, with these words, *I principi tributati da popoli, tributano il servidor loro.* Some imagine that he gave himself the title of *Divine*, signifying thereby that he performed the functions of a god upon earth, by the thunderbolts with which he struck the heads of the highest personages. He used to boast that his lampoons did more service to the world than sermons; and it was said of him, that he had subjected more princes by his pen than the greatest had ever done by their arms. Aretin wrote many irreligious and obscene pieces; such are his dialogues, called *Ragionamenti*. There is likewise imputed to him another very obscene performance, *De omnibus Veneris schematibus*. "It was about the year 1525 (says M. Chevillier, *Origine de l'Imprimerie de Paris*, p. 224) that Julio Romano, the most famous painter of Italy, instigated by the enemy of the salvation of mankind, invented drawings to engrave 20 plates; the subjects are so immodest that I dare only name them. Peter Aretin composed sonnets for each figure. George Vasari, who relates this in his *Lives of the Painters*, says he does not know which would be the greatest impurity, to cast one's eyes upon the drawings of Julio, or to dip into the verses of Aretin." Some say that Aretin changed his libertine principles; but however this may be, it is certain that he composed several theological or pious pieces. He wrote a paraphrase on the penitential psalms, and another on Genesis; the Life of the Virgin Mary, and that of St Catharine of Sienna, and of St Thomas Aquinas. His familiar Letters have been collected, and published in 6 vols. 8vo, Paris, 1609. He was author likewise of various poetical pieces, among which is a tragedy on the subject of the Horatii, possessed of considerable merit. He died in the year 1556, at the age of 65.

ARETOLOGI, in *Antiquity*, a sort of philosophers, chiefly of the Cynic or Stoic school, who frequented the tables of great men, and entertained them in their banquets with disputations on virtue, vice, and other popular topics. These are sometimes also denominated *Circulatores Philosophi*.

AREVALO, a town of Spain, in Old Castile, situated at the junction of the river Adaja with the Arevalillo. Lat. 41. 3. 57. N. and long. 4. 7. 57. W. It contains two magazines for corn, and has 1600 houses and 4500 inhabitants.

AREZZO, a city of Italy, in Tuscany, seated in the territory of Florence, on the declivity of a hill that overlooks the neighbouring plain, between the Citta di Castelli and Florence. It is a bishop's see, subordinate only to the pope, and has two collegiate churches, 15 parishes, 18 religious houses, and four hospitals. It was at one time famous for a kind of earthenware much esteemed by the Romans. It afterwards fell greatly into decay, until Cosmo de' Medici took it under his protection, since which it has been recovering gradually. It is famed for being the birthplace of Mæcenas, of Petrarch, and of Guido Aretin, the great improver of musical notation. A popular insurrection broke out here against the French general Macdonald, in his retreat from Naples to Upper Italy in 1799. 25 miles E.N.E. of Sienna, and 34 S.E. of Florence. Long. 11. 50. E. Lat. 43. 28. N.

ARGEA, or Argoei, in *Roman Antiquity*, thirty human figures made of rushes, thrown annually by the priests or vestals into the Tiber on the day of the ides of May.

ARGELES, an arrondissement in the department of the Upper Pyrenees, in France, extending over 594 square miles, or 380,160 acres. It is divided into five cantons, and subdivided into 102 communes, with 36,912 inhabitants.—The chief city of the arrondissement is of the same name. It is situated in the beautiful valley of Lovedan, on the banks of the Save d'Auzun, with 860 inhabitants.

ARGENCES, a town of France, in Lower Normandy, now the department of Calvados, on the river Meance. Long. 0. 10. W. Lat. 49. 15. N.

ARGENT, the common French word for *silver*. It is used in heraldry to signify purity, beauty, and gentleness.

ARGENTAC, a town of France, in the Limousin, on the river Dordogne. Long. 2. 3. E. Lat. 45. 5. N.

ARGENTAN, an arrondissement in the department of the Orne, in France, extending over 737 square miles, or 470,630 acres. It comprehends 11 cantons, divided into 248 communes, with 115,512 inhabitants.—The chief city of the arrondissement is of the same name. It is situated on an elevation in a beautiful plain, through which the Orne runs. It contains 6195 inhabitants, who make thread-lace of a fine quality, some linen goods, and leather. Around it many feathers are collected from flocks of geese, kept with that object. Long. 0. 3. E. Lat. 48. 44. N.

ARGENTARIUS is frequently used in Roman writers for a money-changer or banker. The argentarii were capitalists, who made a profit either by the changing or lending of money at interest. They had their *tabernæ* or offices in the *forum Romanum*, built there as early as the reign of L. Tarquinius Priscus.

ARGENTEUIL, a town in the arrondissement of Versailles and department of the Seine, on the right bank of the river. It contains 4524 inhabitants. The vicinity yields some wine and abundance of culinary vegetables, and near it are some extensive quarries of gypsum.

ARGENTIERA, a small island in the Archipelago, near Milo. It is about 18 miles in compass, and is full of mountains, producing nothing but barley, cotton, and a few grapes. Long. 23. 10. E. Lat. 36. 50. N.

ARGENTIERE, L', an arrondissement in the department of the Ardeche, in France, extending over 716 square miles, or 458,240 acres, divided into 10 cantons, and again into 104 communes, with 84,909 inhabitants.—The capital of the arrondissement is a city of the same name. It is in a deep valley, in which silk-mills are turned by a stream that runs through it. It contains 390 houses and 1706 inhabitants.

ARGENTINUS, a deity worshipped by the ancients as the god of silver coin; as Æsculanus, whom they made his father, was the god of brass money, which was in use before silver.

ARGENTON, a town of France, divided into two by the river Creuse. Here was formerly a castle, but it was demolished by Louis XIV. Long. 1. 38. E. Lat. 40. 30. N.

ARGENTUM Album, in our old customs, silver coin, or pieces of bullion that anciently passed for money.

Argentum *Dei, God's penny*, anciently signified earnest money, or money given to bind a bargain; in some

Argimna || Argos.

places called *erles* or *arles*, and by the civilians and canonists *arrhæ*.

ARGIMNA, a town of Armenia, in the pachalic of Diarbekir, on the head waters of the Tigris, 40 miles north-west from Diarbekir. It is situated on a lofty mountain, and such is the declivity of the ground, that the houses appear to be piled one above another; and in winter the torrents rush down the streets with such violence as to render them impassable. The town is populous, but wretchedly built, and is remarkable for the quantity of wine and brandy made in its vicinity.

ARGISH, or ARGISCH, the ancient *Arzes*, a town of Armenia, in the government of Van, situated on the north-west side of the lake Van, three days' journey from the town of that name. It contains 6000 inhabitants.

ARGO, in *Antiquity*, a ship or vessel celebrated among the poets, being that wherein the Argonauts, of whom Jason was the chief, made their expedition in quest of the golden fleece. Jason having happily accomplished his enterprise, consecrated the ship Argo to Neptune, or, as others say, to Minerva, in the isthmus of Corinth, where, they add, it did not remain long before it was translated into heaven, and made a constellation.

ARGONAUTS, a company of illustrious Greeks who embarked along with Jason in the ship Argo. "The designs of the Argonauts," says Dr Gillies, in his *History of Greece*, "are veiled under the allegorical, or at least doubtful, phrase of *carrying off the golden fleece;* which, though easily explained, if we admit the report that the inhabitants of the eastern banks of the Euxine extended fleeces of wool in order to collect the golden particles which were carried down by the torrents from Mount Caucasus, is yet described in such various language by ancient writers, that almost every modern who examines the subject thinks himself entitled to offer, by way of explanation, some new conjecture of his own. But in opposition to the most approved of these conjectures, we may venture to affirm that the voyage to Colchis was not undertaken with a view to establish extensive plans of commerce, or to search for mines of gold, far less to learn the imaginary art of converting other substances into that precious metal; all such motives supposing a degree of speculation and refinement unknown in that age to the gallant but uninstructed youth of Thessaly. The real object of the expedition may be discovered by its consequences. The Argonauts fought, conquered, and plundered; they settled a colony on the shores of the Euxine, and carried into Greece a daughter of the king of Colchis, the celebrated Medea, a princess of Egyptian extraction, whose crimes and enchantments are condemned to eternal infamy in the immortal lines of Euripides."

ARGONAUTS *of St Nicholas* was the name of a military order instituted by Charles III., king of Naples, in the year 1382, for the advancement of navigation, or, as some say, merely for preserving amity among the nobles. They wore a collar of shells inclosed in a silver crescent, whence hung a ship with this device, *Non credo tempori*, I do not trust time. Hence these Argonaut knights came to be called *knights of the shell*. They received the order of St Basil, archbishop of Naples, and held their assemblies in the church of St Nicholas their patron.

ARGOS, an ancient name of Peloponnesus, from Argos, one of the kings.

Several ancient cities bore the name of Argos, particularly the capital of Argolis or ARGEIA.

ARGUIN, a small island in a bay of the same name, situated on the western coast of Africa, near the southern termination of the Great Desert. Major Rennell supposes it to be the island to which the ancients, and particularly Hanno, gave the name of Cerne. The Portuguese early formed a settlement there, and even made it for some time the principal point from which they attempted to penetrate into the interior; but the extensive deserts by which it was bordered were very unfavourable for this object, and the banks of the Senegal have been found more advantageous in every respect. The shores round Arguin, however, abound with valuable turtle, and the sea affords a considerable supply of stock fish. Long. 16. 20. W. Lat. 20. 23. N.

ARGUN, ARGAN, or ERGON, a river of Tartary, in the country of the Mongols, which rises from a lake called Dalai, or Koulon-nor, situated in long. 119. 14. E. and lat. 49. N. It is considered to be the original source of the Amur, and by the treaty of Nertschinsk, concluded in 1690, is established as the mutual boundary between the Chinese and Russian empires, from its source to its mouth.

ARGUNSKOI, a town and fortress of Siberia, in the government of Irkutsk, on the west bank of the above river, 162 miles from its mouth. It was first built in 1682, on the opposite side of the river, but was removed to its present site in consequence of the treaty of Nertschinsk. It carries on a considerable trade, but is situated in an extremely cold and inhospitable country. In the neighbourhood are valuable silver mines, and fine gold is frequently extracted from the ore. 177 miles east of Nertschinsk.

ARGUS, in fabulous history, was the son of Aristor, and had 100 eyes, 50 of which were always open. Juno made choice of him to guard Io, whom Jupiter had transformed into a white heifer; but Jupiter, pitying Io for being so closely confined, sent Mercury, who with his flute charmed Argus to sleep, sealed up his eyes with his caduceus, and then cut off his head; when Juno, to reward his fidelity, turned him into a peacock, and placed his eyes in his tail.

ARGUS-SHELL, a species of porcelain shell, beautifully variegated with spots, resembling in some measure those in a peacock's tail.

ARGUTIÆ, witty and acute sayings, which commonly signify something further than the mere words at first sight seem to import.

ARGYLESHIRE or ARGYLLSHIRE, an extensive county in the west of Scotland, is usually described under two great divisions,—the mainland, and such of the Western Islands as are politically attached to it. It is of the former only that we propose to give some account at present, referring to the article HEBRIDES for the islands noted below,[1] which form a part of this county.

The mainland of Argyleshire, situate between 55° 21′ and 57° north latitude, and between 1° 22′ and 3° 25′ of longitude west from Edinburgh, is bounded on the north by Inverness-shire, on the east by the counties of Perth and Dumbarton, on the south by the Irish Sea, and on the west by the Atlantic Ocean; the Frith of Clyde, which separates it from the shire of Renfrew, forming its boundary on the south-east. Its greatest length, from the Mull of Kintyre on the south to the point of Ardnamurchan on the north, is 115 miles; its breadth above 68; and from the windings of the numerous bays and creeks with which the land is everywhere indented, it is suppos-

[1] Those of the first rate are Islay, Mull, and Jura; of the second, Gigha and Cara, Colonsay, Lismore, Tyree, Coll, Ulva and Gometra, Kerreray, Luing, Seil or Saoil; and of the third, Scarba, Lunga, Shuna, Icolmkill or Iona, Eisdale, Inch Kenneth, Staffa, Monk, Rum, and Cannay.

ed to have more than 600 miles of sea-coast. The mainland of Argyleshire is divided into 35 parishes, nine of which are united, reducing the number to 26: two in part belong to Inverness-shire, and only one is altogether inland. The extent of this part of the county is equal to about one thirteenth part of the whole of Scotland, the land comprehending 2200 square miles, and the lakes 60.

General description.

The general features of the country are varied and striking in a high degree, consisting of lofty mountains, deep glens, and inlets of the sea entering far into the land. Towards the northern parts it assumes the wild and savage grandeur so peculiarly characteristic of the Highlands of Scotland. Mountains piled on mountains in magnificent disorder present a sublime, but, in an agricultural point of view, a very unpromising prospect; yet in the most barren districts the hills supply pasture for sheep in considerable numbers; and on the valleys and low grounds are raised oats, bere or big, and potatoes, part of which latter produce is exported. Some of the mountains are among the loftiest in Scotland, particularly Ben Cruachan, which rises 3390 feet above the level of the sea; and on the borders towards the counties of Perth and Dumbarton, the mountains contiguous to Ben Lomond are little inferior to it in height. The inlets of the sea are very numerous. Amongst others are Loch Fine, Loch Etive, Loch Welford, Loch Linnhe, Loch Leven, &c. The district of Kintyre enters into the north channel, and is almost divided from the mainland at the narrow isthmus of Tarbat. The district of Cowal is also nearly peninsulated by Loch Long on the one side and Loch Fine on the other. The interior parts of the county are interspersed with a great number of small fresh-water lakes. A barrenness of soil and scanty vegetation prevail chiefly on the summits of the higher mountains, which exhibit great masses of stratified rocks or groups in a columnar form. Some of the glens are covered with large fragments of these which have been precipitated from the impending cliffs, and consequently afford but scanty pasturage; however, the greater part of them yield good grass. Others of them exhibit miles of fertility, verdure, and cultivation, particularly Glendarual, the most prolific valley of the county. Formerly Argyleshire was interspersed with numerous woods, which, uniting with the lofty mountains, formed the most romantic scenery. But these have been almost all cut down or destroyed to make way for the introduction of sheep; and planting has not, except in a few instances, been carried to any considerable extent. The late duke of Argyle planted very extensively in the neighbourhood of Inverary, and several other gentlemen have followed his example; nevertheless, one of the most striking features in the aspect of the county is its want of wood. Remains of ancient forests are still very extensive in various places; and these consist chiefly of oaks, ashes, pines, and birches. The level of the country towards the southern parts descends the nearest to an equality with that of the sea. The elevation of the country is highest towards the interior parts of the counties of Perth and Inverness.

The fallow-deer, which formerly abounded in the woods and on the mountains, are now only to be seen in the preserves of a few gentlemen; but forest deer are still found in considerable numbers in Glenetive and in Mull. Roes are pretty numerous in the northern parts of the county, and moor game are also found in abundance. The black-cattle, which in former times ran wild on the mountains, are now entirely confined to the low grounds, where their young are fed in winter by the proprietors. Fish are not at all so abundant as is generally supposed; for although white fish are taken in considerable numbers, particularly in the neighbourhood of Campbeltown, still the quantity is small compared with what is taken on other parts of the Scotish coast; and Loch Fine is the only inlet of the sea distinguished for its herring-fishery. There are valuable metals to be found in this county, such as copper, lead, and iron; and also some minerals, particularly strontian.

Agriculture and state of property.

The only crops cultivated to any extent in the mainland of Argyleshire are bere or big, oats, and potatoes. Wheat is raised near Campbeltown, and in other parts of Kintyre; but the quantity is very small, the climate being too wet and variable for its successful cultivation. But the management of potatoes in this district is equal to that of any other part of Scotland, and great quantities are annually exported from it. Turnips and sown grasses are pretty common in the southern, and, among the larger farmers, in the northern districts. Clovers are also frequent; but notwithstanding that these and other green crops are better adapted to the climate than grain, they have not yet come into extensive culture. The principal object in the culture of big is the supply of the distilleries. The great body of the inhabitants live almost exclusively on oatmeal and potatoes, of the former of which they have been in the practice of importing about 20,000 bolls (of 140 lbs.) annually. The progress of agriculture in this county has been greatly retarded, both by the nature of the land and the political condition of the people. Out of 1,408,000 acres, only 125,000 are arable; and these are scattered unconnected over a broad and broken surface, on the sides of hills, or in valleys between rocky eminences, particularly in the northern districts. Another obstacle to improvement will be found in the remains of the feudal system. This county is peopled with a few great proprietors, and a numerous small tenantry, servile in their habits to their superiors, ignorant and indolent in their character, and in their domestic economy presenting all the repulsive features of poverty. Of the valued rent, taken in 1751, of the mainland, with four small islands, amounting to L.9924. 8s. 1d., almost a fourth belongs to two proprietors. This valuation was considered to be equal to the half of the real rent at that period, after deducting all public burdens; but in 1798, when the agricultural survey of the county was published, the gross rental had risen to L.89,000, collected from upwards of 2700 tenants; and in 1811 the rent of the whole county, of which the islands might produce about a fifth, amounted to L.192,073. 14s. 2d. for the lands, and for the houses to L.5208. 18s. 10d. But the most important obstacles to agricultural improvement are inefficient draining, the want of leases, the high rack-rents that are generally exacted, and the system of letting farms to small tenants, who possess the grass in common, and have "rig about" of the arable land, which they exchange with each other every second year. But Kintyre must be an exception from the remarks upon the county in general. In that district agriculture is more encouraged, and consequently more prosperous. Indeed it cannot be denied that the county throughout has been considerably improved, but certainly not to the extent of its resources; and it is to be hoped that the frequent transference of landed property which has taken place within the last fifty years, and the example and encouragement of the late duke of Argyle, the greatest landholder in it, cannot fail to extend a more beneficial system of rural economy. It may be remarked, that of late years considerable numbers of the inhabitants, and those not of the poorest class, have emigrated to America.

Cattle and sheep.

Cattle were long the principal source of the revenue of the landholders and tenantry of Argyleshire; and the native breed, which has been improved of late by more careful treatment, is well known to be equal, if not supe-

Argyleshire.

rior, to any other race of cattle in the kingdom. Their number in 1798 was computed at upwards of 50,000, and they are understood to have increased considerably since; for though they are now excluded from the more elevated tracts, which are better occupied by sheep, the improved management of the lower grounds, small as it is compared with what it might be, has, upon the whole, enlarged the means of their subsistence. These cattle are sent from the country in a store condition, commonly when about three years old, and fatted on the pastures of the south, the greater number for the consumption of England. Dairy husbandry is practised to some extent in the southern parts of Kintyre, where there is a large proportion of arable land; but it cannot be extended to the inland and more mountainous districts of the county.

Until the middle of last century, the only sheep in Argyleshire were of the small native race, and their number was inconsiderable; but these have entirely disappeared, and we do not know that there is a single animal of the breed to be found, except in the most distant islands of the Hebrides. The black-faced is the species that is now almost universally reared. About the period above referred to, coarse-woolled heath sheep were introduced into the higher and more barren districts; and as it was soon discovered that the scanty herbage of these gloomy mountains could be converted into a much greater quantity of mutton than of beef, besides yielding a valuable article of manufacture, these hardy animals soon spread over extensive regions, upon which cattle could barely subsist in the summer months; and the income of the landed proprietors and of the public was accordingly augmented in proportion. At present probably two fifths of the whole rent of land paid in the county arises from the produce of the sheep-farm. Notwithstanding the outcry of ignorance, and the more mischievous speculations of mistaken philanthropy, the introduction of this species of live stock, now increased to about 300,000, has not had the effect of diminishing the population of Argyleshire.

In this division of the county there is a considerable extent of natural coppice-wood, probably near 40,000 acres, which are cut periodically, commonly every 19 or 20 years, and at one time the returns were at the rate of about 20s. per acre annually; but the value of this article has of late greatly diminished. Very extensive plantations have been formed by the duke of Argyle and other proprietors. Those of his Grace are reckoned to contain 2,000,000 of trees, worth 4s. each, amounting to the enormous sum of L.400,000.

Fisheries.

The great extent of sea-coast which Argyleshire possesses, and the nature of the county, penetrated as it is in almost every direction by arms of the sea, and traversed by extensive lakes, afford ample facilities for the prosecution of fisheries; but, either from the unproductiveness of the waters, or the want of vigour and perseverance in the fishermen, with the exception of those of Loch Fine, the fisheries have neither been extensive nor lucrative. The white-fishing especially has been neglected. Enterprising fishermen might certainly greatly increase the produce in this branch, which would be of essential benefit to the inhabitants of so ungenial a territory. In Loch Fine alone, in the years 1794 and 1795, the herrings caught were computed to be worth more than L.89,000 (Smith's *Survey*, 1798); but the fisheries there have of late years greatly fallen off.

Minerals.

The mainland of Argyleshire is principally composed of primitive rocks, which in some quarters are skirted and intermixed with those of the transition class, while flœtz rocks occur very sparingly. No volcanic rocks have hitherto been met with in the mainland of Argyleshire, but those of an alluvial nature abound everywhere. The primitive and transition rocks are stratified, and the general direction of the strata is from north-east to south-west. The primitive rocks are granite, gneiss, mica slate, clay slate, limestone, porphyry, sienite, trap, and quartz rock. The transition rocks are greywacke, greywacke slate, clay slate, trap, and quartz; and the flœtz rocks are red sandstone, conglomerate, and rocks of the coal formation. The islands off the coast of Argyleshire afford highly interesting examples of rocks of the different classes: Isla and Jura, of the primitive and transition rocks; Mull, of flœtz and primitive rocks; Staffa, Rum, and Canny, of flœtz rocks; and Coll, Tyree, and Iona, of primitive rocks.

Coal has been wrought for many years near Campbelltown in Kintyre, and lead at Strontian in Sunart; and besides the slate quarries of Easdale, an island belonging to this county, others have been opened at Ballachelish in Appin, and on the islands of Belnahua, Luing, Seil, and Kerrara.

Manufactures.

Manufactures have made little progress in this district, and no attempts to establish them upon a large scale have yet been successful. Mr Dale endeavoured to extend to it some branches of the cotton manufacture, which failed, it is said, from want of water-carriage; but a number of weavers in Campbeltown and its neighbourhood have been employed for some time in working cottons from Glasgow. The late duke of Argyle established a woollen manufactory near Inverary, which languished for some time, and was finally abandoned many years ago. There is a bleachfield in Kintyre, a tannery at Campbeltown, and another at Oban, which, however, has not been wrought for several years; and there are iron-works in Upper Lorn, belonging to an English company, who bring the ore thither chiefly for the sake of the charcoal which the woods afford. The manufacture of kelp from sea-weed, to the extent of 800 tons annually, is none of the least profitable branches of industry; and that of their scanty crops of grain into ardent spirits, certainly the most pernicious.

Commerce.

The commerce of Argyleshire is also very limited, its exports consisting chiefly of raw produce: sheep, cattle, and fish, form at least two thirds of the whole; and slates, oak bark, and kelp, constitute nearly the remainder. The imports are almost confined to the supply of necessaries, principally oatmeal and flour, and such articles of luxury as habit has rendered scarcely less indispensable.

Thus, notwithstanding its natural advantages, this county is far from being characteristic either of wealth or industry. It was expected that the Crinan Canal, which was cut across the peninsula of Kintyre, at an expense of L.140,000, shortening the voyage from the West Highland and Hebridean ports to the river Clyde about 200 miles, would cause an influx of wealth to the county; but neither it nor the Caledonian Canal, which gives access from the county to the German Ocean, has answered the expectations of the projectors, or contributed in any eminent degree to the prosperity of Argyleshire. Indeed, but for steam navigation, both would have been nearly useless; and even with that accessory, there is no adequate return for the vast sums expended on them.

History.

This county still contains many ancient monuments, which display the warlike spirit of its former inhabitants. In the course of the eighth and ninth centuries it was conquered, along with the neighbouring isles, by the Danes and Norwegians. For five or six centuries it continued under the dominion of Norway, and during that period was under the direct administration of feudal chieftains, generally of Norwegian extraction, who each maintained an almost independent government. Along with the Hebridean isles, all the western parts of Argyle became the conquest of the Scotish monarchs in the 14th century. Some time after, Macdonald, the representative of

this region, obtained leave from the Scotish crown to hold his possessions as a feudatory to that kingdom; but, from his turbulent spirit, he and his family were engaged in perpetual rebellions, which were at last punished by the forfeiture of their estates, which, along with their titles, were bestowed on the Campbells; and these have ever since retained them in peace and loyalty, beloved and honoured by their country. The county of Argyle gives the title of *Duke* and *Earl* to the chief of this family, who likewise enjoys several other important posts under the crown. His vassals are so numerous, that in former times he could on occasion bring 3000 or 4000 fighting men into the field. This clan is numerous in Argyleshire, and there are a great number of castles and seats belonging to gentlemen who hold of the duke, and boast themselves descended from his family.

The county sends one member to parliament; it is also the seat of a provincial synod. It contains two royal boroughs and 49 parishes.

The population of the whole county, as taken under the last population acts of 1811 and 1821, will be seen from the following tables.

1811.

DISTRICTS.	HOUSES.			OCCUPATIONS.			PERSONS.		
	Inhabited.	By how many Families occupied.	Building and Uninhabited.	Families chiefly employed in Agriculture.	Families chiefly employed in Trade, Manufactures, or Handicraft.	All other Families not comprised in the two preceding classes.	Males.	Females.	Total of Persons.
Argyle	2702	3720	76	1568	545	1607	7729	7908	15637
Cowal	1212	1276	44	789	329	158	3318	3569	6887
Islay	2636	2687	1162	1284	615	788	6814	7348	14162
Kintyre	2959	3733	62	1074	924	1735	8404	9882	18286
Lorn	2721	2845	353	1064	752	1029	6462	7317	13779
Mull	3010	3107	24	2642	254	211	7948	8886	16834
	15240	17368	1721	8421	3419	5528	40675	44910	85585

1821.

DISTRICTS.	HOUSES.			OCCUPATIONS.			PERSONS.		
	Inhabited.	By how many Families occupied.	Building and uninhabited.	Families chiefly employed in Agriculture.	Families chiefly employed in Trade, Manufactures, or Handicraft.	All other Families not comprised in the two preceding classes.	Males.	Females.	Total of Persons.
Argyle	2966	3343	43	1887	504	952	8648	8802	17450
Cowal	1327	1402	40	501	372	529	3874	3858	7732
Islay	2892	3122	48	2246	447	429	8476	8517	16993
Kintyre	2823	4014	57	869	895	2250	9584	10814	20668
Lorn	2827	3091	141	1246	826	1019	7584	7686	15270
Mull	3224	3337	1040	2240	424	673	9339	9864	19203
	16059	18309	1369	8989	3468	5852	47505	49541	97316

ARGYRASPIDES, or ARGYROASPIDES, in *Antiquity*, persons armed with silver bucklers, or bucklers silvered.

ARIADNÆA, in *Grecian Antiquity*, two festivals at Naxos, in honour of two women named *Ariadne*. One of them being the daughter of King Minos, they had, in the solemnity dedicated to her, a show of sorrow and mourning; and, in memory of her being left by Theseus near the time of child-birth, it was usual for a young man to lie down and counterfeit all the agonies of a woman in labour. This festival is said to have been first instituted by Theseus, to atone for his ingratitude to that princess.—The other Ariadne was thought to be of a gay and sprightly temper, and therefore her festival was observed with music and other expressions of mirth and joy.

ARIADNE, daughter of Minos, king of Crete. Theseus being sent to destroy the Minotaur, Ariadne was so taken with him, that, as a testimony of her love, she gave Theseus a clue of thread to guide him out of the labyrinth. Theseus, having killed the Minotaur, carried off the Athenians he had relieved, together with Ariadne, whom, however, he afterwards forsook.

ARIANCOOPAN, a small town of Hindostan, on the sea-coast of the Carnatic, which in 1748 was taken by Admiral Boscawen. The fortifications have long disappeared; and the place still belongs to the French, who have a church here, and resort to it on festival days. 3 miles south of Pondicherry. Long. 79. 52. E. Lat. 11. 54. N.

ARIANO, a city of the Principato-Ultra in Naples, with 10 churches and convents, and 11,718 inhabitants.

ARIANS, followers of Arius, a presbyter of the church of Alexandria about the year 315, who maintained that the Son of God was totally and essentially distinct from the Father; that he was the first and noblest of those beings whom God had created, the instrument by whose

subordinate operation he formed the universe, and therefore inferior to the Father both in nature and dignity; also, that the Holy Ghost was not God, but created by the power of the Son. The Arians owned that the Son was the *Word*, but denied that the *Word* was eternal. They held that Christ had nothing of man in him but the flesh, to which the Λογος or Word was joined, which was the same as the soul in us. The appellation of *Arian* has been indiscriminately applied in more modern times to all those who consider Jesus Christ as inferior and subordinate to the Father, and whose sentiments cannot be supposed to coincide exactly with those of the ancient Arians. Mr Whiston was one of the first divines who revived this controversy in the beginning of the 18th century. He was followed by Dr Clarke, who published his famous book entitled *The Scripture Doctrine of the Trinity*, in consequence of which he was reproached with the title of *Semi-Arian*. Dr Waterland, who has been charged with verging towards Tritheism, was one of his principal adversaries. The history of this controversy may be found in a work entitled *An Account of all the considerable Books and Pamphlets that have been wrote on either side, in the Controversy concerning the Trinity, from the Year* 1712; *in which also is contained an Account of the Pamphlets written this last year on each side by the Dissenters, to the end of the year* 1719; published in London in 1720.

ARIAS Montanus, a learned Spanish divine, employed by Philip II. of Spain to publish another edition of the Bible after that of Cardinal Ximenes, which he finished with applause, and died at Seville in 1598.

ARICINA, in *Mythology*, a surname of Diana, under which appellation she was honoured in the forest Aricine, so called from Aricia, a princess of the blood-royal of Athens.

ARIENZO, a city of Naples, in the province of Lavoro. It stands on a hill, with an ancient castle overlooking it, contains seven parish churches, an hospital, and 10,770 inhabitants, including the populous suburbs.

ARIES, in *Astronomy*, a constellation of fixed stars drawn on the globe in the figure of a ram. It is the first of the twelve signs of the zodiac, from which a twelfth part of the ecliptic takes its denomination.

ARIMANIUS, the evil god of the ancient Persians. The Persian magi held two principles—a good demon or god, and an evil one; the first the author of all good, and the other of all evil: the former they supposed to be represented by light, and the latter by darkness, as their truest symbols. The good principle they named *Yezad* or *Yesdan*, and *Ormozd* or *Hormizda*, which the Greeks wrote *Oromasdes;* and the evil demon they called *Ahriman*, and the Greeks *Arimanius*. Some of the magians held both these principles to have been from all eternity; but this sect was reputed heterodox, the original doctrine being that the good principle only was eternal, and the other created.

ARIOLI, in *Antiquity*, a kind of prophets or religious conjurers, who, by abominable prayers and horrible sacrifices at the altars of idols, procured answers to their questions concerning future events. Isid. *Orig.* lib. viii. cap. 9. These are also called *harioli*, and their operation *hariolation*. Sometimes they were denominated *aruspices* or *haruspices*. The *arioli* were distinguished by a slovenly dress, disorderly and matted beards, hair, &c.

ARION, an excellent musician and poet, inventor of dithyrambics. Periander entertained him at his court, where, getting an estate, and returning to Corinth, the sailors, in order to possess themselves of his money, threw him into the sea, when, according to the poets, a dolphin, charmed with his music, took him on her back and carried him safe to shore.

Arion, an admirable horse, much more famous in poetic history than Bucephalus in that of Alexander. Authors speak variously of his origin, though they agree in giving him a divine one. His production is most commonly ascribed to Neptune. This god, according to some, raised him out of the ground by a stroke of his trident; according to others, he begot him upon the body of the fury Erinnys; according to others, upon that of Ceres, whom he ravished in the form of a horse, she having previously assumed the form of a mare to elude his pursuit. This horse was nursed by the Nereids; and being sometimes yoked with the sea-horses of Neptune to the chariot of this god, he drew him with incredible swiftness through the sea. He had this singularity in him, that his right fect resembled those of a man. Neptune gave him to Capreus, king of Haliartus. Capreus made a present of him to Hercules, who mounted him when he took the city of Elis, gained the prize with him in the race against Cygnus, the son of Mars, near Trœcena, and at last made a present of him to Adrastus. It is under this last master that Arion has signalized himself the most: he won the prize at the Nemean games, which the princes who went to besiege Thebes instituted in honour of Archemorus; and was the cause that Adrastus did not perish in this famous expedition, as all the other chiefs did.

ARIOSTO, Lodovico, one of the greatest poets of Italy, was born at Reggio in Lombardy, on the 8th day of September 1474. His father was Niccolò Ariosto, commander of the citadel of Reggio, and his mother Daria Malaguzzi of that city, where the family still exists. He showed a strong inclination to poetry from his earliest years, but was obliged by his father to study the law—a pursuit in which he lost five of the best years of his life. Having obtained liberty to follow his inclination, he applied himself to literature; and he intended to peruse the classics under Gregorio da Spoleti. But after having had the benefit of this learned man's instructions for a short time, during which he read the best Latin authors, he was deprived of it, Gregorio having gone to France as tutor of Prince Sforza; and he thus lost the opportunity of learning Greek, as he intended. His father dying soon after, he was compelled to forego his literary occupations to undertake the management of the family, whose affairs were embarrassed, and to provide for the subsistence and education of his nine brothers and sisters, one of whom was a cripple. He, however, wrote some comedies in prose, and some lyrical pieces, about this time; and was then appointed one of the gentlemen of the cardinal Ippolito of Este. This prince usurped the character of a patron of literature, whilst the only reward which the poet received for having dedicated to him the *Orlando Furioso*, was the question, Where did you find so many stories, Master Ludovic? The poet himself tells us that the cardinal was ungrateful; deplores the time which he spent under his yoke; and adds, that if he received some miserable pension, it was not to reward him for his poetry, which that prelate despised, but to make some just compensation for the poet's running like a messenger, with risk of life, at his eminence's pleasure. Nor was even this miserable pittance regularly paid during the period that the poet enjoyed it. The cardinal went to Hungary in 1518, and wished Ariosto to accompany him. The poet excused himself, pleading ill health, his love of study, the care of his private affairs, and the age of his mother, whom it would have been disgraceful to leave. His excuses were not received, and even an interview denied to him. Ariosto then boldly said, that if his eminence thought to have bought a slave by assigning him the scanty pension of seventy-five crowns a year, he was mistaken, and that he might withdraw his boon, which it seems that prelate did.

Alfonso, duke of Ferrara, then received Ariosto among his courtiers, which was an act of pure justice, that poet having distinguished himself as a diplomatist, chiefly on being sent twice to Rome as ambassador to the Pope Giulio II. The fatigue of one of these hurried journeys brought upon him a complaint from which he never recovered; and on his second mission he was nearly killed by orders of that violent pope, at that time much enraged against the duke of Ferrara. On account of the war, his salary of only 84 crowns a year was suspended, and withdrawn altogether after the peace; in consequence of which Ariosto asked the duke either to provide for him, or to allow him to go to seek employment elsewhere. A province belonging to that sovereign, situated on the wildest heights of the Apennines, being then without a governor, Ariosto was sent thither in that character, and remained there for three years. This was not a sinecure. The province was distracted by factions and banditti, the governor had not the requisite means to enforce his authority, and the duke did not support his minister as he ought. Yet it is said that Ariosto's government satisfied both his sovereign and the people confided to his care; and a story is added of his having fallen in, when walking out alone, with a party of banditti, whose chief apologized to the governor for not having immediately shown to him that respect which his rank required.

Although he was dissatisfied with his office, he would not accept an embassy to Pope Clement VII., which the secretary of the duke offered him; and spent the remainder of his life at Ferrara, writing comedies, superintending their performance, as well as the construction of a theatre, and correcting his *Orlando Furioso*, of which the complete edition was published only in 1532. He died of a consumption on the 6th of June 1533.

That he was honoured and respected by the first men of his age is a fact; that most of the princes of Italy showed him great partiality is equally true; but they limited their patronage to kind words. It is not known that he ever received any substantial mark of their love for literature: he lived and died poor. He proudly wrote, on the entrance of a house built by himself,

> Parva, sed apta mihi, sed nulli obnoxia, sed non
> Sordida, parta meo sed tamen ære domus;

which serves to show the incorrectness of the assertion of flatterers, followed by Tiraboschi, that the duke of Ferrara built that house for him. The only one who seems to have given any thing to Ariosto as a reward for his poetical talent is the marquess del Vasto, who assigned him an annuity of one hundred crowns on the revenues of Casteleone in Lombardy; but it was only paid, if ever, from the end of 1531. That he was crowned as poet by Charles V. seems untrue, although a diploma may have been issued to that effect by the emperor.

The character of Ariosto seems to have been fully and justly delineated by Gabrielle, his brother:—

> Ornabat pietas et grata modestia Vatem,
> Sancta fides, dictique memor, munitaque recto
> Justitia, et nullo patientia victa labore,
> Et constans virtus animi, et clementia mitis,
> Ambitione procul pulsâ, fastusque tumore.

His satires, in which we see him before us such as he was, show that there was no flattery in this portrait. From these compositions (the interest of which is only equalled by the elegance as well as *naïveté* of the poetry, and the shrewdness of observation of human nature which the poet displays), we are highly pleased with a noble sentiment of independence displayed by Ariosto. He seems to have been very fond, and even jealous, of his liberty. He was, moreover, of a changeable disposition, which he very frankly confesses in his Latin verses, as well as in the satires.

> Hoc olim ingenio vitales hausimus auras
> Multa cito ut placeant, displicitura brevi.
> Non in amore modo mens hæc, sed in omnibus impar
> Ipsa sibi longa non retinenda mora.

Hence he never would bind himself, either by going into orders or marrying, till towards the end of his life, when he married Alessandra, widow of Tito Strozzi. He had no issue by her, although he left two natural sons by different mothers.

His Latin poems do not perhaps deserve to be noticed, because, in the age of Flaminio, Vida, Fracastoro, and Sannazzaro, and from a poet like Ariosto, we have a right to expect better things. His lyrical compositions show a poet, although they do not seem worthy of Ariosto. His comedies, of which he wrote four, besides one which he left unfinished, are avowedly imitated from Plautus and Terentius; and although natives may admire in them the elegance of the diction, the liveliness of the dialogue, and the novelty of some scenes, few will feel interest either in the subject or in the characters, and none will approve the immoral passages with which they are disfigured—a fault more to be reproached to the audience and the patrons of theatrical representations in those days than to the poet.

Of all the works of Ariosto, however, the most solid and best known monument of his fame is his poem the *Orlando Furioso*, the extraordinary merits of which have cast into oblivion the numberless romance poems which inundated Italy during the 15th, 16th, and 17th centuries.

The popularity which a poem, now shamefully neglected, the *Orlando Innamorato*, by Bojardo, enjoyed in Ariosto's time, cannot be well conceived, now that the enthusiasm of the Crusades, and the interest which was attached to a war against the Moslems, are no longer felt. Bojardo wrote and read his poem at the court of Ferrara, but died before he was able to finish it. Many poets undertook the difficult task of completing that magnificent work; but it was reserved to Ariosto both to finish and to surpass his original. Bojardo did not perhaps yield to Ariosto either in vigour or in richness of imagination, but he lived in a less refined age, and died before he was able to put a finishing hand to that part of the poem which he had written yielding to the impulse of his exuberant fancy; but Ariosto united to a powerful imagination a refined taste and an elegant mind. He began to write his poem about 1503; and after having consulted the first men of the age of Leo X., he published it in 1516, in only 40 cantos; and up to the moment of his death never ceased to correct and improve both the subject and the style. It is in this latter quality that he excels, and for which Italians gave him the name of *Divino Lodovico*. When jesting he never forgets that he was a gentleman; when attempting pathetic descriptions or narratives, he searches the reader's deepest feelings. In his machinery he displays a vivacity of fancy with which no other poet can vie; but he never lets his fancy carry him so far as to omit to employ, with an art peculiar to him, those simple and natural pencil-strokes with which he gives to the most extraordinary feats a colour of reality which conciliates our reason without undeceiving our bewildered imagination. The death of Zerbino, the complaints of Isabella, the effects of discord among the Saracens, the flight of Astolfo to the moon, the passion which causes Orlando's madness, teem with beauties of every species. It is to be observed that the supposition that the poem of Ariosto is not connected throughout is utterly unfounded; there is a connection which, with a little attention,

will become evident. The love of Ruggero and Bradamante forms the main subject of the *Furioso;* and every part of it, except some episodes, depends upon this subject. The poem ends with the marriage of these two personages. (G. G.)

ARIPO, a town on the western coast of the island of Ceylon, at the mouth of the river Sarunda. To the east of this town is a bank, where they fish for pearls. Long. 80. 25. E. Lat. 8. 42. N.

ARISTÆUS, son of Apollo and Cyrene, whom, for the many services he had rendered to mankind by his knowledge of all profitable arts, the gods placed among the stars.

ARISTANDER, a famous soothsayer under Alexander the Great, over whom he gained a wonderful influence by the good success of his art. He had already had the same employment at the court of King Philip; and it was he who explained better than his brethren the dream that this prince had after having married Olympias.

ARISTARCHUS, a Grecian philosopher of Samos, one of the first who maintained that the earth revolves round the sun. He was the contemporary of Cleanthes, the successor of Zeno. The opinion ascribed to him with respect to the motion of the earth is not to be found in his only existing work, namely his *Treatise of the Greatness and Distance of the Sun and Moon.* It was first published at Venice in 1498; and has been reprinted at Oxford, both separately and in the 3d volume of Wallis's works.

ARISTARCHUS, a celebrated grammarian, much esteemed by Ptolemy Philometer, who committed to him the education of his son. He applied himself chiefly to criticism, and made a revisal of Homer's poems, but in too magisterial a way; for such verses as he did not like he treated as spurious. He commented on other poets. Cicero and Horace made use of his name to express a very rigid critic.

ARISTIDES, surnamed the *Just*, one of the most celebrated characters of his age for purity and integrity, and contemporary with Themistocles, was the son of Lysimachus, a man of middle rank, and born at Athens. His dispositions and temper from his youth all conjoined in anticipating that greatness to which he afterwards rose. To a firm, resolute, and placid temper, he likewise added a great contempt of dissimulation, and an utter abhorrence of every thing dishonourable. He began very early to meditate on subjects of government, and applied to his studies with the greatest assiduity. He imbibed a strong predilection for oligarchy upon becoming acquainted with the laws of Lycurgus, which excited his admiration, and gave him a distaste of the unlimited democracy then established in his native city. On the other hand, Themistocles favoured democracy; and even when at school he is said to have been his constant antagonist on that point. A perpetual opposition to one another in all political points was the consequence of this difference of opinion, when their abilities raised them to several important stations in the state. It is related, that one day having firmly opposed a proposal of Themistocles in the assembly, which in his own conscience he knew to be right, on coming out he exclaimed, "The affairs of the Athenians will never prosper till they throw both of us into the *barathrum*" (the dungeon for condemned criminals).

Aristides was present at the battle of Marathon, fought B. C. 490, and was next in command among the Athenians to Miltiades; and there, upon that general's proposing to come to battle as soon as possible, he seconded his motion with the utmost vigour. In the field he distinguished himself by his intrepidity, valour, and generosity; and being left after the battle to secure the spoils, he executed his trust with honour and fidelity, bringing all to the public account, reserving nothing for himself. He was elected to the important office of chief magistrate the year following; but, by the art of Themistocles, the high authority he had attained by his merits was at length converted into an accusation against him, and he was accordingly banished by the ostracism,—a mild but often unjust measure in the policy of the Athenian state, for getting a temporary relief from the presence of any political influence by which they thought their independence might be injured. As the Persians were meditating a new invasion of Greece, he employed himself in his exile in encouraging the Greeks to defend their liberties against the invaders. The Athenians immediately, upon the approach of Xerxes, recalled Aristides, whose absence they began sincerely to regret, along with their other exiles. At this critical moment, upon his return, he suspended all political animosities; and upon understanding that it was the design of Themistocles to fight the Persian navy in the Straits of Salamis, he waited on him in private, proposed an oblivion of all past circumstances, extolled his intentions, and gave him his sincere promise to do the utmost in his power towards effecting his designs. Themistocles, some time after the battle of Salamis, acquainted the Athenians that he had formed a scheme which, although it was of such a nature as forbade his public avowal of it to them, was of inestimable advantage to the state. They immediately ordered that he should communicate it to Aristides. It was a project for consuming the whole confederate fleet of Greece by fire, except their own ships; and thus the entire sway of the sea would be left to the Athenian navy. Aristides reported that nothing could be more unjust, and at the same time nothing more advantageous, than the scheme of Themistocles. Upon this report the people immediately determined to drop any further thought of it. Aristides, before the battle of Platæa, was of considerable service in persuading his countrymen, who were elated with their former successes, to submit to the superior power of the Spartans, and in preserving peace and amity between the confederate forces. He acquitted himself with great valour and resolution in the engagement, and was appointed after the victory to determine a very dangerous dispute concerning the honour of the day, which he conferred upon the Platæans, giving up the claim of the Athenians, the Lacedemonians following his example. Upon the rebuilding of Athens, he was the first person to promote a law which divided the administration among the citizens at large, and enjoined that the archons or chief magistrates should be elected out of the whole body of the people, who had so deservedly merited the favour of the state.

Aristides, upon the continuation of the war with the Persians, was sent, along with Cimon the son of Miltiades, to take the command of the Athenian forces in the confederate army. Their humility and meekness, compared with the haughty domineering temper of Pausanias, so engaged the rest of the allies, that the superiority of rank was conferred upon Athens, with the joint concurrence of the other states. The nomination of Aristides to lay an equal assessment upon all the states for the purpose of defraying the expense of the war, was a signal proof of the high idea all Greece had of his integrity and justice. The wisdom and impartiality with which he performed this commission gave universal satisfaction. He obliged all the confederates, after this affair was terminated, solemnly to swear to all the articles of association. The advice which he afterwards gave the Athenians to extend their own territories beyond their proper limits, must certainly have proceeded from some very pressing necessity, when he thus drew down the consequences of the perjury upon his own head. Aristides, on Themistocles's falling under the displeasure of the ruling party, would not con-

cur in a capital prosecution of him; and instead of triumphing over an old enemy, he always spoke of him after his banishment with the highest respect.

This great man died about 407 years B. C., according to some at Athens, at an advanced age; others say at Pontus, where he was transacting public business. He was buried at the public expense, his daughters received portions out of the public treasury, and an estate in land was bestowed on his son Lysimachus, in gratitude for the signal services Aristides had done his country.

ARISTIDES, *Ælius*, a celebrated orator, born in Mysia about 129 years before the Christian era. The best edition of his works is that of Oxford, printed in Greek and Latin, in two volumes quarto.

ARISTIDES, a painter contemporary with Apelles, flourished at Thebes about the 122d Olympiad. He was the first, according to Pliny, who expressed character and passion, but he was not remarkable for softness of colouring.

ARISTIPPUS, the founder of the Cyrenaic sect of philosophy, was the son of Aretades, and born at Cyrene in Libya. He flourished about the 96th Olympiad. The great reputation of Socrates induced him to leave his own country and remove to Athens, that he might have the satisfaction of hearing his discourses. He was chiefly delighted with those discourses of Socrates that related the most to pleasure, which he asserted to be the ultimate end in which all happiness consists. His manner of life was agreeable to his opinion, for he indulged himself extremely in all sorts of luxuries. Though he had a good estate, yet he was the only one of the disciples of Socrates who took money for teaching. Upon his leaving Socrates he went to Ægina, as Athenæus informs us, where he lived with more freedom and luxury than before. Socrates sent frequent exhortations to him in order to reclaim him, but all in vain; and with the same view he wrote that discourse which we find in Xenophon. Here Aristippus became acquainted with Laïs, the famous courtesan of Corinth, for whose sake he took a voyage to that city. He continued at Ægina till the death of Socrates, as appears from Plato's *Phædo*, and the epistle which he wrote upon that occasion. He returned at last into his own country, Cyrene, where he professed philosophy, and instituted a sect which, as we observed above, was called the *Cyrenaic*, from the place, and by some writers the *Hedonic* or voluptuous, from its doctrines.

We have many apophthegms of his preserved. To one who asked him, what his son would be the better for being a scholar, "If for nothing else," said he, "yet for this alone, that when he comes into the theatre one stone will not sit upon another." When a certain person recommended his son to him, he demanded 500 drachmas; and upon the father's replying that he could buy a slave for that sum, "Do so," said he, "and then you will be master of a couple." Being reproached because, having a suit of law depending, he fee'd a lawyer to plead for him, "Just so," said he, "when I have a great supper to make I always hire a cook." Being asked what was the difference between a wise man and a fool, he replied, "Send both of them together naked to those who are acquainted with neither of them, and then you will know." Being reproached for going from Socrates to Dionysius, he replied, "That he went to Socrates when he wanted serious instruction, and to Dionysius for diversion." Having received money of Dionysius, at the same time that Plato accepted a book only, and being reproached for it, "The reason is plain," says he, "I want money and Plato wants books." Being cast by shipwreck ashore on the island of Rhodes, and perceiving mathematical schemes and diagrams drawn upon the ground, he said, "Courage, friends; for I see the footsteps of men."

Having visited Dionysius the Sicilian tyrant, and lived a long time at his court, his daughter Arete sent to him to desire his presence at Cyrene in order to take care of her affairs, since she was in danger of being oppressed by the magistrates; but he fell sick in his return home, and died at Lipara. With regard to his principal opinions, like Socrates, he rejected the sciences as they were then taught, and pretended that logic alone was sufficient to teach truth and fix its bounds. He asserted that pleasure and pain were the criterions by which we were to be determined; that these alone made up all our passions; that the first produced all the soft emotions, and the latter all the violent ones. The assemblage of all pleasures, he asserted, made true happiness, and that the best way to attain this was to enjoy the present moments. He wrote a great many books, but none of them has been preserved. It has been shown by M. Luzac, in his *Lectiones Atticæ*, that he was not the author of the treatise on the *Luxury of the Ancients*, frequently ascribed to him; nor of the *Epistles* given as his in the Socratic collection of Leo Allatius.

ARISTO, a Stoic philosopher, the disciple of Zeno, flourished about 290 years before the Christian era. He differed but little from his master Zeno. He rejected logic as of no use, and natural philosophy as being above the reach of the human understanding. It is said that being bald, the sun burnt his head; and that this caused his death.

ARISTOCRACY, a form of government by which the supreme power is vested in the principal persons of the state. The word is derived from αριστος, *optimus*, and κρατεω, *impero*, I govern. See the article GOVERNMENT.

ARISTOGITON, a famous Athenian, who, with Harmodius, killed Hipparchus, tyrant of Athens, about 513 years before the Christian era. The Athenians erected a statue to him.

ARISTOPHANES, a celebrated comic poet of Athens. He was contemporary with Plato, Socrates, and Euripides; and most of his plays were written during the Peloponnesian war. His imagination was warm and lively, and his genius particularly turned to raillery. He had also great spirit and resolution, and was a declared enemy to slavery, and to all those who wanted to oppress their country. The Athenians suffered themselves in his time to be governed by men who had no other views than to make themselves masters of the commonwealth. Aristophanes exposed the designs of these men with great wit and severity upon the stage. Cleon was the first whom he attacked, in his comedy of the *Equites;* and as there was not one of the comedians who would venture to personate a man of his great authority, Aristophanes played the character himself, and with so much success, that the Athenians obliged Cleon to pay a fine of five talents, which were given to the poet. He described the affairs of the Athenians in so exact a manner that his comedies are a faithful history of that people. For this reason, when Dionysius, king of Syracuse, desired to learn the state and language of Athens, Plato sent him the comedies of Aristophanes. He wrote above 50 comedies, but there are only 11 extant which are perfect: these are, Plutus, the Clouds, the Frogs, Equites, the Acharnenses, the Wasps, Peace, the Birds, the Ecclesiazusæ or Female Orators, the Thesmophosiazusæ or Priestesses of Ceres, and Lysistrata. The Clouds, which he wrote in ridicule of Socrates, is the most celebrated of all his comedies. Having conceived some aversion to the poet Euripides, Aristophanes satirizes him in several of his plays, particularly in his Frogs and his Thesmophosiazusæ. He wrote his Peace in the 10th year of the Peloponnesian war, when a treaty of 50 years was concluded between the

Athenians and the Lacedemonians, though it continued but seven years. The Acharnenses was written after the death of Pericles and the loss of the battle in Sicily, in order to dissuade the people from intrusting the safety of the commonwealth to such generals as Lamachus. Soon after he represented his Birds, by which he admonished the Athenians to fortify Decelæa, which he calls by a fictitious name, *Nephelococcygia*. The Vespæ, or Wasps, was written after another loss in Sicily, which the Athenians suffered from the misconduct of Chares. He wrote the Lysistrata when all Greece was involved in war; in which comedy the women are introduced debating upon the affairs of the commonwealth, when they come to a resolution not to go to bed with their husbands till a peace should be concluded. His Plutus, and other comedies of that kind, were written after the magistrates had given orders that no person should be exposed by name upon the stage. He invented a peculiar kind of verse, which was called by his name, and is mentioned by Cicero in his Brutus; and Suidas says that he also was the inventor of the tetrameter and octameter verse.

Aristophanes was greatly admired among the ancients, especially for the true Attic elegance of his style. The time of his death is unknown; but it is certain that he was living after the expulsion of the tyrants by Thrasybulus, whom he mentions in his Plutus and other comedies.

There have been many editions of the works of Aristophanes. The *editio princeps*, printed by Aldus at Venice in 1498, in folio, is a rare and beautiful volume. The best edition is that of Brunck, printed at Strasburg in 1781–3, in 4 vols. 8vo, and reprinted at Oxford in 1810. Nicodemus Frischin, a German, famous for his classical knowledge in the 16th century, translated Plutus, the Clouds, the Frogs, the Equites, and the Acharnenses, into Latin verse. Quintus Septimus Florens rendered into Latin verse the Wasps, the Peace, and Lysistrata; but his translation is full of obsolete words and phrases. Madame Dacier published, at Paris, in 1692, a French version of Plutus and of the Clouds, with critical notes, and an examination of them according to the rules of the theatre. Mr Lewis Theobald likewise translated these two comedies into English, and published them with remarks. Mr Cumberland gave a translation of the Clouds in his *Observer*, accompanied with an able view of the life and genius of the author. A translation of the greater part of Aristophanes, with introductions of considerable length, has been published by Mr Mitchell, in 2 vols. 8vo, Lond. 1820–22.

ARISTOTELIA, in *Antiquity*, annual feasts celebrated by the citizens of Stagyra, in honour of Aristotle, who was born there; and in gratitude for his having procured from Alexander the rebuilding and repeopling of that city, which had been demolished by king Philip.

ARISTOTLE.

The power of philosophy in fixing an impression of itself on the world, appears, when attentively viewed, no less than that evidenced in successful exertions of civil or military talents. But there is a striking difference in the comparative interest excited by the philosopher himself, and the distinguished statesman or general. The personal fortunes of the philosopher are not connected with the effects of his philosophy. He has passed away from the eyes of men, when his powerful agency begins to be perceived; whereas the statesman and the commander of armies are implicated in the very effects which they produce on the world, and the history which tells of their policy or their conquests assumes almost the character of their biographies.

This contrast is strongly displayed in the instance of the particular philosopher whose life we would now retrace. At this day, after the lapse of twenty-one centuries from its first appearance, we are experiencing the power of Aristotle's philosophy, in its effects on language and literature, and even on theology; and yet little satisfactory information can be obtained from antiquity respecting the philosopher himself. No account of him appears to have been given until his celebrity had attracted envy as well as admiration; so that we are compelled to receive with suspicion every thing beyond the simple detail of a few facts.

Stageirus,[1] a city of the Thracian Chersonese, a Greek colony originally from the island of Andros, and afterwards from Chalcis, was the birth-place of Aristotle. His father was Nicomachus, physician to Amyntas, king of Macedonia; his mother Phæstis: both being of Chalcidian descent. His family referred its origin to Machaon, son of Esculapius; probably from the hereditary profession of medicine by which it was distinguished.[2] The date of his birth is B. C. 384.

Being left an orphan in early youth, Aristotle quitted Stageirus for Atarneus in Mysia, the residence of Proxenus, the friend to whose guardianship he was committed. Here he continued until his seventeenth year, when he repaired to the great university of the world at that time —the school of Plato at Athens. Different accounts are given of the commencement of his application to philosophy. By one it is ascribed to a direction of the Pythian oracle.[3] Others state that philosophy was a last resource with him, when other schemes of life had failed; that, having exhausted a large patrimony, he became a military adventurer, and after that a seller of drugs; until at length, on accidentally entering the school of Plato, he received a sudden impulse to the studies of his future life. These last statements, however, are not reconcilable with the period of youth at which his discipleship to Plato began; nor are they quite consistent with the alleged fact, that his mind had been from the first trained to philosophical pursuits by his father Nicomachus.[4]

We can readily suppose that the extraordinary talent for science, and laborious devotion to it, which his mature age developed, would give some indications of themselves in his earlier years. Hence the expressions attributed to Plato, complimenting him as "the intellect of the school," and "the reader," and comparing his ardour and forwardness to the spirit of a restive colt.[5]

He remained at Athens, a hearer of Plato, twenty years; leaving it only on the death of that philosopher, B. C. 348, and then returning to Atarneus. Disappointment at not succeeding to the chair of Plato in the academy, has been assigned as the reason of his departure.

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[1] It is also written Stageira and Stageiri. We have the authority of Herodotus and Thucydides for Stageirus.
[2] Diog. Laert. in *Aristot.*; Dionys. Halicar. *De Demosth. et Aristot.*; Ammon. in *Aristot.*
[3] Ammon. in *Aristot.*
[4] His father Nicomachus has the reputation of being the author of some philosophical works.
[5] Diog. Laert. in *Aristot.*; Ammon. in *Aristot.*; Ælian. *Var. Hist.* iv. 9.

All that appears, however, is, that he left Athens in compliance with an invitation from Hermeias,[1] who, having been his fellow-disciple in the school of Plato, had established himself at that time in independence against the king of Persia, as tyrant of Atarneus and its neighbourhood. Here he spent the following three years of his life, when the unhappy end of his friend Hermeias, who fell a sacrifice to his ambition, and was executed as a rebel against Persia, compelled him to seek a refuge for himself by flight to Mitylene. Nor did he in this extremity forget the ties of friendship which had connected him with the unfortunate tyrant of Atarneus. To support the fallen family, he married Pythias, the adopted daughter, but variously described both as the sister and as the niece,[2] of Hermeias.

From Mitylene he proceeded into Macedonia to the court of Philip, and entered on a new scene of exertion, as the preceptor of the future sovereign of the mightiest kingdom of the world—Alexander the Great, at that time a youth of fourteen years of age. The call to such an office argues the high reputation already attained by Aristotle for philosophy, though it is not improbable that his first introduction to the Macedonian court was through the interest and favour enjoyed there by his father Nicomachus. At what time, indeed, his care of the youthful prince commenced, it is not possible exactly to determine. A letter is extant, addressed by Philip to Aristotle, which would imply that the charge of the prince's education had been committed to the philosopher from the birth of Alexander. This is also far more probable than that the charge should have been postponed until the prince had reached his fourteenth year, the period at which the actual residence of Aristotle at Pella is dated. Philip states in that letter that "a son is born to him; that he is grateful to the gods, but not so much for the birth of the boy, as that he was born in the time of Aristotle; trusting that, being nurtured and trained up by the philosopher, he would be a worthy successor to his father's glory and the conduct of affairs."[3] It is certainly very possible that a plan of education proposed by Aristotle may have been carried on by others, until the more especial care of the intellectual powers demanded his personal instructions. The reception of the philosopher by the royal family was most friendly and honourable to him. The high estimation in which he was held was shown in the influence he possessed at the Macedonian court. Philip, it is said, gave him liberal supplies of money to enable him to pursue his philosophical labours.[4] He was most happy in the admiration and affection of his pupil. Alexander valued his instructions as those of a second parent, observing that "he was no less indebted to Aristotle than to his father, since it was through his father indeed that he lived, but through Aristotle that he lived well."[5]

It would be interesting to know what particular method was pursued by Aristotle in the education of Alexander; but we have no exact information on this point. It appears certain, however, that he made the cultivation of a taste for literature the great principle of his instructions; and this would be in conformity with the plan of education proposed in his treatise of politics. He is known, indeed, to have made a new collection of the Iliad expressly for the use of Alexander, and to have composed for him a treatise *On a Kingdom*, not extant among his works. And how deeply the youthful king had imbibed the Homeric spirit in the discipline of his early years, was evidenced in his after-life, by the heroism with which his actions were conceived, and the poetry, if we may so express it, which mingled with the realities of his eventful history. The circumstances alone, that the Iliad was constantly at the pillow of Alexander during his expeditions, and was treasured by him with extraordinary care in the precious casket of the spoils of Darius,[6] are characteristic of the tone of mind which his preceptor's instructions had, if not formed, at least strengthened and improved. Nor is it inconsistent with this ultimate effect, that Aristotle should have communicated to his royal pupil the abstruse doctrines of his philosophy. And that he did so, we have evidence in Alexander's complaint, in a letter to Aristotle, of the publication of the secret wisdom in which he had himself been disciplined; and in the reply from Aristotle, "that the books alluded to were as if they had not been published, since without his oral instruction they would be unintelligible."[7] Plutarch, indeed, attributes to Aristotle's instructions the fondness for medical study and practice remarkable in Alexander.[8]

A life of such premature exertion as that of Alexander left comparatively little time for the mere business of philosophical instruction. Succeeding to the throne of his father at the age of 20, he was from that time immersed in affairs of policy and war; and even previously, he had been forwardly engaged in the services of the field, as also for a short interval in the conduct of the government. Still the society of Aristotle appears to have been cherished by him, so that the philosopher continued a resident at the court for two years after the accession of Alexander; leaving Macedonia only on the occasion of Alexander's setting out on his Asiatic campaigns, B. C. 334.[9] It is probable that Aristotle was indisposed to the hurry and restlessness of military expeditions, and longed for a repose more congenial to his taste in the philosophic bowers of the suburbs of Athens; and circumstances had prepared the way for the separation. For though Alexander, it seems, never entirely lost his respect for his preceptor, the cordiality of their intercourse had in some measure abated. A commencement of alienation in the feelings of Alexander had been evidenced.[10] Aristotle, accordingly, embraced the opportunity then offered of returning to Athens; and Callisthenes of Olynthus, his relative and pupil, supplied his place among the party of philosophers by whom the king was accompanied in the Asiatic expedition.

It was fortunate for science that the intercourse be-

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[1] Commonly called Hermeias the eunuch.

[2] Aristippus, according to Laertius, says it was the mistress of Hermeias that Aristotle married.

[3] Aulus Gellius, *Noct. Att.* ix. 3. The genuineness of the letter has been doubted, but without sufficient reason, if the only ground of doubting it is, that it could not have been received by Aristotle at Mitylene.

[4] Ælian. *Var. Hist.* iv. 19. The statement of Hermippus (Diog. Laert. in *Aristot.*), that Aristotle served in the capacity of ambassador from the Athenians to Philip, seems inconsistent with other established facts of his life.

[5] Plutarch in *Alex.* Diog. Laertius in *Aristot.* attributes to Aristotle himself a general expression to the same effect.

[6] Plutarch in *Alex.* whence it obtained the name of "the Iliad," ἐκ τοῦ κιβωτίου, "of the casket."

[7] Plutarch in *Alex.* Aulus Gellius, *Noct. Att.* xx. 5. This literary jealousy on the part of Alexander appears also from a passage of Aristotle, where, writing to Alexander (*Rhet. ad Alex.* 1), he says, "you have charged me in your letter that no other person should receive this book."

[8] Plutarch in *Alex.*

[9] Ammonius, in his *Life of Aristotle*, asserts that Aristotle accompanied Alexander into Asia, and conferred with the Brahmans, where he composed "the two hundred and fifty Polities." How much credit may be attached to this author, appears from his making Aristotle a disciple of Socrates for three years, whereas Socrates had been dead sixteen years before the birth of Aristotle.

[10] Plutarch in *Alex.*

tween the king and the philosopher was not broken off by their separation. The conquests of Alexander presented singular opportunities for a collection of observations on natural history. Under the superintendence, accordingly, of Aristotle, some thousands of persons, it is said, were employed in making inquiries on the subject throughout Asia and in Greece: and we have still valuable fruits of these inquiries, in a *History of Animals*, in ten books, extant among the works of Aristotle; though this history must be but a small part of the fifty volumes to which Pliny says it extended.[1]

In the absence, however, of Aristotle, an event occurred which had the effect of exciting most unjust surmises against him, and involving him in unmerited disgrace with Alexander. A conspiracy was formed against the life of the king by some noble youths who attended on his person. The conspirators were detected and punished; but the chief blame of the whole affair rested on Callisthenes, to whom the education of the young men had been especially committed, and under whose sanction, accordingly, they were conceived to have acted in their traitorous designs. The imputation was the more credible, as Callisthenes had distinguished himself for his opposition to the adulation of the courtiers, and the rude freedom with which, in spite of the admonitions of Aristotle,[2] he asserted his democratic principles. How far he was really guilty may admit a doubt. A pretext at least was afforded for the removal of an obnoxious individual; and Callisthenes was imprisoned, and died a violent death. His connection with Aristotle gave a plea for extending the charge to Aristotle himself; who, it is represented, became so fearful of the result to himself, after the death of Callisthenes, as to have been actually instrumental to the murder of the king. He is stated to have sent a very subtle poison, called Stygian water, in a mule's hoof, the only material impregnable to it, to Antipater, and thus to have occasioned the death of the king.[3] The account itself is sufficiently refuted by the real state of the case, which shows that Alexander fell a sacrifice to his intense exertions in an unhealthy climate. It was probably propagated by the rival sophists who surrounded the person of Alexander; and to the same source may be ascribed the first estrangement of the king, and his increased aversion to the philosopher in consequence of the affair of Callisthenes. Alexander pointedly showed his increased dislike, by sending a present of money to Xenocrates; thus placing that philosopher, as well as Anaximenes, whom he also now more particularly noticed, in triumphant contrast with Aristotle, as the objects of his patronage.[4]

In the mean time Aristotle was pursuing his proper path of exertion at Athens as a lecturer in philosophy, in his own school of the Lyceum. There is no good reason for supposing that he was actuated in forming a separate school, as some have asserted, by contemptuous opposition to Xenocrates, or jealousy of the rhetorical fame of Isocrates.[5] His own fame already stood sufficiently high. Numbers resorted to him for instruction. In the morning and evening of each day he was thronged with hearers; the morning class consisting of his more intimate and peculiar disciples, the evening class of hearers of a more general description. The distinction of these two classes corresponds with the difference between his "acroamatic" and his "exoteric" philosophy. The application of these terms to the writings of Aristotle has been much controverted. The most simple account of their difference appears to be, that the acroamatic or esoteric were more of text-books, notices of various points of philosophy to be filled up by the previous knowledge of the learner and the explanations of the philosopher, as lectures addressed to his own proper class; the exoteric were more elaborate and popular disquisitions, more expanded in the reasonings, more diffuse in the matter.[6] His disciples obtained the appellation of Peripatetics; but the reason of this is also controverted. Perhaps, like some other party-names, it was originally given in contempt.[7]

The reputation of Aristotle at length rose to a dangerous popularity. The intolerant spirit of paganism viewed with suspicion the spread of philosophical doctrines, as tending to unsettle the existing government through their effect on the vulgar superstition. This had been strikingly shown at Athens not long before the birth of Aristotle in the fate of Socrates.[8] In the case of Aristotle there were enemies watching to apply the policy of the state to the cruel purposes which their envy had suggested. For twelve years, it seems, no opportunity of attack presented itself; since he continued his philosophical labours at Athens for that time. Probably the name of Alexander had been itself a shelter to him against their malice. But the alienation of the royal favour gave an opening to their designs; and, on the death of Alexander, B. C. 323, he became the marked object of persecution. Through the agency of the hierophant Eurymedon, with whom was associated a powerful citizen, by name Demophilus, a direct accusation of impiety was brought against him before the court of Areopagus. He was charged with introducing doctrines adverse to the religion of Greece.[9] It was alleged that he had paid divine honours both to Hermeias and Pythias; to the former by a hymn in praise of his virtue, to the latter by celebrating her memory (for she was now dead) with the Eleusinian rites,[10] and to both by statues of them erected at Delphi. He saw that he had no chance of a favourable hearing against so formidable a conspiracy, and that his death was fully determined by his enemies, knowing too well the malignant sycophancy[11] which domineered at Athens. Instead, therefore, of confronting the charge, he made his escape to Chalcis, alleging to his friends, in allusion to the death of

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[1] Plin. viii. 16.

[2] Aristotle is said expressly to have cautioned Callisthenes in the words of Thetis to Achilles (*Iliad*, xviii. 95):

Ὠκυμορος δη μοι, τεκος, εσσεαι, δι' αγορευεις.

"Brief life, my son, is destined for such words."

And generally to have admonished him to converse, either very seldom, or else most complaisantly, with the king. Valer. Maxim. vii. 2. Diog. Laert. in *Aristot.*

[3] Arrian. *Exp. Alex.* vii. 27.; Plin. xxx. 16; Xiphilin. in *Caracalla;* Qu. Curtius, viii. 6; Brucker, *Hist. Crit. Philos.* in *Aristot.*

[4] Diog. Laert. in *Aristot.*; Brucker, *Hist. Crit. Philos.* in *Xenocrat.* vol. i. p. 734.

[5] Diog. Laert. in *Aristot.*; Cicero, *Tusc. Qu.* i. 4; *Orator.* iii. 35; Quinctil. *Inst. Orat.* iii. 1.

[6] Aulus Gellius, *Noct. Att.* xx. 5; Plutarch in *Alex.*

[7] The practice of teaching in walking was not peculiar to Aristotle (Ælian. *Var. Hist.* i. 19; Diog. Laert. iii. 11; Brucker, *Hist. Crit. Philosoph.* vol. i. p. 783). Indeed the term περιπατον was applied to "discussion" before the time of Aristotle. Aristophanes uses it humorously in *Ran.* 940, 951, in this sense. The custom appears to have been for the hearers to sit at the lectures of the philosophers. Cleon, in *Thuc.* iii. 38, compares the assembly to "persons sitting spectators of sophists."

[8] B. C. 400.

[9] See Origen. *con. Cels.* i. p. 52, ii. p. 68.

[10] The profanation of the mysteries was not an unknown occurrence at Athens. See *Thuc.* vi. 28, 61.

[11] Well described by him in a line from Homer, Ογχνη επ' ογχνη γηρασκει, συκον δ' επι συκῳ, comparing it, with allusion to the etymology of the word, to the perpetual fruitage of the gardens of Alcinous.

Socrates, "that he was unwilling to involve the Athenians in a second crime against philosophy."[1]

He did not long survive his retreat to Chalcis—little more, probably, than a year. He was then advanced in life, and broken with bodily infirmities as well as with dejection of spirit. On the approach of death, he declared his wish, it is said, with regard to his successor at the Lyceum. Theophrastus of Lesbos and Menedemus of Rhodes were the most conspicuous candidates for that honour; but the dying philosopher, avoiding a pointed rejection of either, delicately intimated his preference of Theophrastus by calling for cups of Lesbian and Rhodian wine, and, when he had tasted them, simply observing, ἡδιων ὁ Λεσβιος, *the Lesbian is the sweeter.*[2] The expression was the more appropriate, as sweetness was the characteristic of the eloquence of Theophrastus.

The mode of his death is variously related. One account is, that he died from vexation at not being able to explain the current of the Euripus.[3] Another story, less incredible than this, asserts that he drank aconite, in anticipation of the judgment of the Areopagus.[4] The only probable account is, that he died from a natural decay of the powers of the stomach, his constitution being worn out by excessive watching and study. How exhaustless his application of mind was, may be judged from the anecdote related of him, that in composing himself to rest, he used to hold a brass ball in his hand in such a way, that the noise of its falling into a basin underneath it might awaken him from his slumbers.[5] Another anecdote to the same effect is, that on some occasion of sickness, he observed to the physician prescribing for him, "Treat me not as you would a driver of oxen or a digger, but tell me the cause, and you will find me obedient."[6]

His fellow-citizens showed great respect to his memory. They conveyed his body to Stageirus, and erected a shrine and altar over his tomb. In gratitude also for the restoration of their city, effected through his interest with the Macedonian court, and the new code of laws which he had been permitted to frame for them, they instituted a festival called Aristoteleia, and gave the name of Stageirite to the month in which the festival was held. Plutarch says that even in his time they showed the stone seats and shaded walks of the philosopher.[7] The grant of a gymnasium had been among the advantages which he had obtained for his native city.

Aristotle was twice married. After the death of Pythias, by whom he had a daughter of the same name, he married Herpyllis, a fellow-citizen. By Herpyllis he had a son, Nicomachus, who became a disciple of Theophrastus, but died in battle at an early age.[8] He adopted also as a son, Nicanor, the son of Proxenus, the friend of his youth, and by the directions of his will gave his daughter Pythias to him in marriage. Pythias, by her third husband Metrodorus, had a son named after the philosopher.

In his extant will we have a pleasing evidence of his amiable concern for his surviving family. It contains affectionate provisions, not only for his wife and children, but even for his slaves; expressly enjoining that no one of those who had served him should be sold, but that each should be freed on attaining manhood, according to his deserts.[9]

The fondness of the Greeks for apophthegm has handed down some reputed sayings of the philosopher, the genuineness of which, however, is extremely questionable, from their want either of spirit or of originality. The following, if true, would throw some light on his character. On being reproached for giving alms to a worthless person, his answer is said to have been, "It was not the disposition, but the man, that I pitied;" on hearing that he had been reviled by some one, "When I am absent, he may even scourge me;" to a talkative person, asking him whether he had not exhausted him with trifling, "No, indeed, for I have not been attending to you."[10]

In body, Aristotle, if we may believe the accounts of his person, was deficient in the requisite symmetry. He is described as having slender legs and little eyes. To these defects were added a feeble voice and hesitating utterance.[11] Unlike philosophers in general of that age, he attended to the ornament of his person. His hair was shorn; he wore several rings; and was elegant throughout in his dress.[12] His health was infirm; but he sustained it by habits of temperance, and by that medical skill which he possessed in an eminent degree, so as to protract his life to the 63d year, B. C. 322.

Of his moral qualities, the zeal of philosophical rivalry has transmitted the most discordant accounts. Some have been as extravagant in their praises as others have been in their censures. By some, his patriotism, his affection for his friends, and reverence for his preceptor Plato[13]—his moderation, and modesty, and love of truth—have been held up to admiration. By others, again, no crime has been thought too bad to be imputed to him. He has been stigmatized as a parasite, as gluttonous, effeminate, sordid,[14] ungrateful, impious. Among his faults, too, have been mentioned a sneering cast of countenance, and an impertinent loquacity. In particular, he has been accused of assailing Plato with captious questions, and forcing the old man, then in his 80th year, to retire to the privacy of his garden.[15] Whilst, however, the circumstances in which he lived, exalted as he was by the favour of kings, and by eminence in philosophy, afford a strong presumption that the dark side of the picture has at least been overcharged,[16] we have a more decisive evidence to the truth of the favourable representations of his character in the temper and spirit of his extant writings. Throughout these, there is a candour, and manliness, and love of truth, strikingly discernible; not professedly set forth, but interwoven with the texture of his discussions, and rather betrayed unconsciously than demanding to be recognized. His ethical writings, especially, breathe a pure morality, such as we find in no antecedent philosopher; a morality also avowedly practical, and by which he would have stood self-condemned had his own conduct been at variance with it.

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[1] Diog. Laert. in *Aristot.*; Ammon. in *Aristot.*; Origen. *con. Cels.* i. p. 51. edit. Cantab.; Ælian. *Var. Hist.* iii. 36; Athenæus, xv. 16.
[2] Aulus Gellius, *Noct. Att.* xiii. 5.
[3] Justin Martyr, *Coll. ad Græc.*; Greg. Nazianz. *Orat.* iii. p. 79; Bayle, *Dict.* art. *Aristot.* note z.
[4] Hesych. in *Aristot.*; Suidas, *Fabric. Bibl. Gr.* vol. ii. p. 109; Diog. Laert. in *Aristot.*
[5] Diog. Laert. in *Aristot.*
[6] Ælian. *Var. Hist.* ix. 23.
[7] Plutarch in *Alex.*
[8] Aristocles apud Euseb. *Præp. Ev.* xv. 2.
[9] Diog. Laert. in *Aristot.*
[10] Diog. Laert. in *Aristot.* The same author mentions an instance of Aristotle's foiling the cynic Diogenes in some premeditated witticism, and gives some expressions by which Aristotle characterized certain philosophers, such as calling Socrates "a short-lived tyranny." The point of these passages, at any rate, escapes the modern reader.
[11] Diog. Laert. τραυλος την φωνην.
[12] Diog. Laert.; Ælian. *Var. Hist.* iii. 19.
[13] Ammonius says he dedicated an altar to Plato, inscribing it to him as "a man whom for the bad even to praise would be profane."
[14] Hence the story of his selling the oil which he had used medicinally about his person. (Diog. Laert. in *Aristot.*)
[15] Ælian *Var. Hist.* iii. 19.
[16] See Aristocles apud Euseb. *Præp. Ev.* xv. 2.

ARISTOTLE'S PHILOSOPHY.

Aristotle's Philosophy.

Account of the Writings of Aristotle, and reception of his Philosophy.

The preservation of the original writings of Aristotle is a curious fact in literary history. Whilst the philosopher distributed his other property to his surviving family, he left the more precious bequest of his writings to Theophrastus, his favourite disciple and successor in the Lyceum. By Theophrastus they were bequeathed to Neleus, by whom they were conveyed from Greece into Asia Minor, to the city of Scepsis, where he resided. The heirs of Neleus, to whom they next descended, were private individuals, not philosophers by profession, who were only anxious for the safe custody of their literary treasure. The magnificence of kings had then begun to display itself in the collection of libraries, and the works of genius were sought out with an eager and lavish curiosity. It was a taste happy for the cause of literature; to which, perhaps, the example of Alexander's noble fondness for every thing connected with intellectual energy had principally led. Aristotle himself, indeed, is said to have been the first to form a library.[1] He was the first, probably, to form one on an extensive scale. The Scepsians, into whose hands his works had now fallen, fearful of the literary rapacity of the kings of Pergamos, resorted to the selfish expedient of secreting the writings under ground. The volumes remained in this concealment until at length their very existence seems to have been forgotten; and they would thus have been lost to the world, but for the accidental discovery of them after the lapse of 130 years. His philosophy had been traditionally propagated, for we hear of Peripatetics at this time. Portions, indeed, of his works probably had continued in circulation among the disciples of the Lyceum, serving in some measure as a record of the principles of the sect. Much may have been preserved from memory, for we have little notion now of the impression made by *viva voce* instruction, when it was the only channel of knowledge to the generality. A peripatetic philosopher, accordingly, Apellicon of Teos, whom Strabo, however, characterizes as a lover of books rather than a philosopher—φιλοβιβλος μαλλον η φιλοσοφος[2]—purchased the recovered volumes, and effectually retrieved them for the world. He employed several copyists in transcribing them, himself superintending the task. Unfortunately, much was irreparably lost, the writings being mouldered with the dampness of the place in which they had so long been deposited. In addition to these damages of time, they were now further impaired by misdirected endeavours to restore the effaced text of the author.

The works of Aristotle thus, through the care and the wealth of Apellicon, found their way back to Athens, their proper soil, though no longer perfect as the author had left them. Here they remained until the spoliation of the city by Sylla. The library of Apellicon was a tempting object of plunder to the Romans, who were now awakened to the value of literature; and Aristotle's works accordingly were carried away to Rome amidst the other rich spoils. At Rome they experienced a better fortune. Tyrannio, a learned Greek, who had been a prisoner of war to Lucullus, and was then enjoying the freedom granted to him as a resident at Rome, was the principal instrument in their future publication. Obtaining access to the library of Sylla, he made additional copies of the writings. His labours were followed by Andronicus the Rhodian, who at length edited the works of Aristotle, at a distance of nearly 300 years from the time when they were composed.[3]

Meanwhile other sects in philosophy had sprung up, and engaged the attention of the world. The Stoics and the Epicureans, among others, had formed their respective parties. Platonism had obtained permanent establishment at Alexandria. The disciples of Aristotle, on the contrary, had to struggle against the disadvantage of the loss of the authoritative records of their master's philosophy. When, however, these records were fully published, they were studied with extraordinary eagerness. A multitude of commentators arose, who exercised a profound ingenuity in explaining the genuine sense of the philosopher. As Aristotle himself by his personal teaching had transcended the fame of his contemporaries, so his philosophy rose up from its long sleep to triumph over every other that had previously engaged the public mind. Platonism, indeed, modified as it was by Ammonius and his successors, continued to be fostered in the early ages of the Christian church, in consequence of the theological cast which it had assumed, and its facility of accommodation to Christian truth. But in the progress of the church, when Christianity demanded to be maintained, not so much by accession from the ranks of paganism, as by controversial ability within its own pale, a more exact method of philosophy was required. Here, then, the philosophy of Aristotle asserted its pre-eminence.

But it was only a partial Aristotelian philosophy that was at first established. His dialectical treatises had been studied during the ascendancy of Platonism, for their use in arming the disputant with subtle distinctions, and enabling him accurately to state his peculiar notions in theology. The same occasion still existed for the acuteness of the expert dialectician, even after the decline of Platonism, in the state of theological controversies. It was still, therefore, chiefly as a dialectical philosopher, through the several treatises which pass under the name of the *Organon*, that Aristotle was known throughout Christendom. In western Europe, indeed, the cloud of ignorance which had covered the lands with thick darkness, limited the attainments even of the learned to a narrow field. The original language of Aristotle's philosophy was gradually almost forgotten, and the generality were restricted to such parts of his writings as were translated by the happier talent and industry of the few, who shone as luminaries in the night of the middle ages. The peculiar exigencies of the times, probably the taste of the learned themselves, led to the translation in particular of the dialectical treatises. The treatise on the Categories appears to have been the one principally known

[1] Strabo, xiii.

[2] *Ibid.* xiii. p. 609. Aristocles in Euseb. *Præp. Ev.* xv. 2, speaks of Apellicon as the author of some writings on Aristotle.

[3] Plutarch in *Sylla;* Bayle's *Dict.* art. Tyrannio, note D; Brucker, *Hist. Crit. Philos.* vol. i. p. 799. Andronicus flourished about B. C. 60. The rise of philosophy at Rome was contemporary with him. Cicero in *Tusc. Qu.* i. 1, says, "Philosophia jacuit usque ad nostram ætatem." He speaks, too, in *Fin.* iii. 3, of finding "commentarios quosdam Aristotelios," in the villa of Lucullus. Athenæus, i. p. 3, says the books of Aristotle were sold by Neleus to Ptolemy Philadelphus, and conveyed into the Alexandrian library. This may also be true of detached portions of Aristotle's works, or copies of such portions.

among Christians. Nor were these translations always made from the original Greek; but, on the contrary, were in most instances versions of versions. For its knowledge of Greek literature, western Europe was indebted to Arabic civilization. The Arabians had, together with their conquests in Spain, imported their knowledge of the Greek philosophy, the seeds of which had been scattered in the East by the learning of the Nestorian Christians. Translations had been made into Arabic, of the Greek authors, and among these, of Aristotle. Jews at the same period were resident in great numbers in Andalusia, the principal seat of Arabic literature; and these, by their commercial intercourse with Christians and Mahometans, served as a channel through which the Greek philosophy was carried on from the Spanish Arabians to the Christians of the West. For the purpose of communication, the Arabic versions of Aristotle were translated into Latin, the universal language of early European literature; and thus was the foundation laid of that scholastic philosophy, through which the dominion of Aristotle was afterwards extended over Europe.

But the occupation of Constantinople by the Latins, in the beginning of the 13th century, was the opening of a new era in the literary history of Europe. Greater facilities were afforded by this event for the knowledge of the Greek language; and Aristotle began to be no longer known chiefly as a logician. His physical, metaphysical, and moral treatises were more extensively explored and studied; though at first objection was made to the physics by the papal authority. He was thenceforth fully recognized under the title of *Princeps Philosophorum.* His dialectic, indeed, maintained its ascendancy in the scholastic philosophy; but it was not applied exclusively, as at first, to theology. It was carried into those new subjects of inquiry which the extended knowledge of his writings had introduced to the learned. The spirit of disputatious subtilty, which, in the beginnings of the scholastic philosophy, had displayed itself in the quarrels between the Nominalists and Realists, afterwards found employment in the application of logical principles to speculations in physics and metaphysics. At the same time theology became more and more corrupted by the refinements of systematic exposition, until at length the accumulated mass of error became too evident to be borne, and, among other causes, produced a re-action in the reformation of the church.[1]

The abuse of the Aristotelian philosophy, thus mischievously shown, tended greatly to shake the empire which it had held over the minds of men. Had Luther stood alone in the work of reform, Aristotle would have been altogether banished from the schools of the reformed. But his roughness of hand was tempered in this point, as in others, by the milder spirit of Melanchthon.

Melanchthon, though he had too deep an acquaintance with classical literature not to feel the charm of Plato's writings, yet justly vindicated the superiority of Aristotle's philosophy as a discipline of the mind. He was therefore instrumental in supporting the dominion of Aristotle in the schools, whilst he rejected the errors to which the peripatetic philosophy had falsely administered.[2] Afterwards the disputes among Protestants themselves served to perpetuate the re-established philosophy of Aristotle, and, from the same cause as before, the subtilties of his Dialectic and Metaphysics were studied rather than the more practical parts of his system. Thus, even after the labours of Bacon in dispelling the mists which the Aristotelian philosophy, such as it descended through the doctors of the scholastic ages, had diffused, Aristotle's works continued to be read and taught in Protestant universities. His philosophy, during an empire of centuries, had occupied so many posts in the field of literature, that no system, however great an improvement, could at once displace it; for we find even Bacon himself, in the process of counteracting it, and introducing his own method, compelled to use a phraseology founded on the dogmas of the scholastic creed.

It is then of great importance to examine the system of Aristotle in its authentic records. Such an examination will convince us that the philosopher is not to be censured for that depravation of philosophy to which he was made subservient; but that, had his system been rightly understood, and pursued in the spirit of its author, the schoolmen could never have found in it just ground for the extravagances into which they deviated. We are compelled, indeed, to take our estimate of it from such imperfect relics as time has spared to us out of a far greater mass of his original writings.[3] Fortunately, however, those relics include a great variety of treatises, affording a specimen at least of his mode of philosophizing in every department of science.

State of Philosophy before Aristotle. General Character of his Philosophy.

Aristotle was the first philosopher who really separated the different sciences, and constituted them into detached systems, each on its proper principles. Before his time philosophy had existed as a vast undigested scheme of speculative wisdom, fluctuating in its form and character according to the circumstances and the genius of its leading professors.

Thus the two great fountains of Grecian science—the Italic school, founded by Pythagoras—the Ionic, by Thales—were both in their principle mathematical; though, when we look to their actual results, as they were moulded by their respective masters, the Italic may be characterized as the Ethical school, the Ionic as the Physical. Both appear to have been drawn from the same parent-source of Egyptian civilization and knowledge. That mystic combination of mathematical, physical, and moral truth exhibited in the theological philosophy of Egypt, found a kindred spirit in Pythagoras. Hence that solemn religious light shed over his speculations. Mathematical truth was the basis of his system. He made numbers the elements of all existing things; the objects of the physical world being conceived by him to be "imitations," or "representations," of the abstract natures of numbers.[4] But the system, as a whole, was a mysterious contemplation of the universe, addressed to the moral and devotional feelings of man. Thales was a philosopher of a much more simple cast. Like Pythagoras, he was devoted to mathematical study. He is said to have instructed the Egyptians how to measure the height of their pyramids by means of the shadows; and several of the theorems of the elements of Euclid are attributed to him. But he did not, like Pythagoras, fall into the error of confounding and blending the facts of

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[1] Roger Bacon, *Opus Majus*, part i. p. 13, 19, ed. Jebb, Lond.; Lewis's *Life of Wickliffe*; Lewis's *Life of Bishop Pecock*; Mosheim's *Eccles. Hist.* vol. ii. p. 216, 218, Lond. 1823; Pegge's *Life of Bishop Grosseteste*; *Recherches Critiques sur l'Age et l'Origine des Traduct. Lat. d'Aristote*, par M. Jourdain, p. 16, 81, 94, Paris, 1819.

[2] Melanchthon in *Aristot. et Platon.* ii. p. 370, iii. p. 351; Bayle's *Dict.* art. Melanchthon, note K.; Brucker, *Hist. Crit. Phil.* iv. p. 282.

[3] Diog. Laert. in *Aristot.* συνεγραψε δε παμπλεισια βιβλια.

[4] *Metaph.* i. 6, ii. p. 848, Du Val. *Metaph.* xii. 3. p. 974.

Aristotle's Philosophy.

natural philosophy with the abstract truths of science. According to him, it was sufficient to show that water might be regarded as the primary element of all things. He sought no deeper cause in any speculation concerning the mode in which this element subsisted. The successors of Pythagoras and Thales variously modified the theories of those great masters. The physical philosophy, however, of Thales, as the more simple and intelligible, and probably also from the greater intercourse of Greece with its Asiatic colonies than with its Italian, more especially prevailed in Greece; until we find Socrates, who had been the disciple of Archelaus of that school, complaining that the concerns of human life had been abandoned for the subtilties of physics. In the hands of Socrates philosophy resumed its moral complexion. Had it devolved on Xenophon to take the lead as the successor and interpreter of Socrates, things would probably have continued in this course, and ethical science would henceforth have triumphed in the Grecian schools. But the genius of Plato succeeded to the rich patrimony of the Socratic philosophy: and Plato was not one, whose ambition could be content with less than the reputation of founding a school, or whose imagination could be tied down to the realities of human life.[1] The mystical theory of numbers taught by Pythagoras must have possessed a powerful charm for such a mind as that of Plato: at the same time his power of eloquent discussion found its own field of exertion, in speculation on those moral truths with which the lessons of Socrates had inspired him. He had also been a hearer of Cratylus,[2] and through him had been instructed in the theory of the "perpetual flux" of nature, the favourite doctrine of Heraclitus. Plato accordingly applied himself to the combination of these various systems. The theory of Pythagoras was to be retained consistently with the perpetual change of all existing things according to Heraclitus, and with the immutability of nature implied in the Socratic definitions. Definitions could not apply to any perceptible objects, if it were allowed that all such objects were constantly changing; nor could numbers sufficiently account for that immense variety of objects which the universe presented. There must therefore be some existences, independent of the perceptible universe, to serve as the objects of definitions; and there must be also an infinity of various architypes, corresponding to the various classes of external objects. Hence he devised his doctrine of ειδη, or ideas; a doctrine naturally suggested to an imaginative mind, by the fixedness and universality of the terms of language, as contrasted with the perpetual variation of the course of nature. To these abstract natures he assigned a real being, as objects of intellectual apprehension alone, accounting for the existence of sensible objects from their "participation" of these intellectual universals. Thus he raised a structure of physical philosophy on a basis of metaphysics and logic conjointly; or, in other words, philosophy, in its passage through the school of Plato, had been invested with a dialectical character. Dialectic, the science, according to Plato, which speculates on these universals of the intellectual world, was held forth to the student in wisdom as the dominant philosophy, the consummation and end of all sciences.[3]

Such was the state of philosophy when Aristotle began to teach, and in which he had himself been trained: but it was not a system in which his penetrating mind could rest satisfied. He thought too deeply and accurately, not to discover that this cardinal doctrine[4] of Platonism, the doctrine of ideas, specious as it was, was only a shadowy representation of the real objects of philosophy;[5] and that, in order to rest the sciences on a sure basis, a more exact analysis of the principles of human knowledge was required. He accordingly addressed himself to the task of developing a *really intellectual* system of nature, in the stead of that imaginary intellectual system which the enthusiasm of Plato had created.

He found the different sciences separated from their roots, and vegetating only as stunted branches on a stock of dialectic unnatural to them. Even dialectic itself, in this state of things, was neglected. Its proper nature was unknown in that conjunction of logic and metaphysics which had usurped its name; and its relation to the other sciences was misapprehended. In overthrowing the doctrine of ideas, therefore, he had to make an entire reform of philosophy. And, in fact, he did appear no less as a reformer of the ancient philosophy, than Bacon was of the scholastic system. In each case, idols were enthroned in the niches and shrines of the temple of science; and the hand of the reformer was required to cast them down and break them in pieces. If indeed we impartially consider the case, we shall find that Aristotle was animated by the same spirit which dictated the method of the inductive philosophy, and that his reform was directed to the same points. It was his object, as well as Bacon's, to recall men, from their unprofitable flight to universals, to the real course of nature; and to direct them in the discovery of sure principles of science.

He was the first, accordingly, to exhibit a particular science drawn out into its proper system. There was, for instance, a great deal of logical and of moral truth scattered through the writings of Plato; but there was no regular statement of the principles either of logical or moral science, no distinct collection of the proper facts of those sciences, until the treatises of the Organon and the Nicomachean Ethics of Aristotle appeared. We may easily conceive the arduousness and importance of this service in the cause of philosophy. For any reformer to have fully carried it into effect in every science, we may indeed pronounce to be impossible. And we shall not wonder, therefore, that in some instances he should have failed, or have merely indicated the proper path of inquiry.

It was not indeed to be expected, that one trained in the dialectical philosophy of Plato should have emerged at once from the prejudices imposed by that system. Aristotle, though professedly opposed to the realism involved in Plato's doctrine of ideas, yet betrays the power of language over his own speculations, by the importance which he attributes to abstract conceptions as the foundations of scientific truth. It is a delusion, which the simple attention to the phraseology of one language (and there is no evidence that Aristotle knew any other language but his own) is apt to produce. In the analysis of the terms, we lose sight of the merely arbitrary connection between the terms and the objects designated by them, and suppose that we have penetrated into the

[1] Aristotle (*Rhet.* ii. 23) mentions that Aristippus, alluding to Plato's ambitious manner of expression on some point of philosophy, remarked, αλλα μην ὁγ' ἑταιρος ἡμων, ουδεν τοιουτον, "our friend, at any rate (meaning Socrates), has nothing of the kind."

[2] Cratylus found fault with his master Heraclitus for saying that "a man had never been twice on the same river; for no one," he said, "had ever been even once." (*Metaph.* iv. 5.) This was but a natural extension of the doctrine of Heraclitus.

[3] Αρ' ουν δοκει σοι, ἐφην ἐγω, ὡς περ θρυγπος τοις μαθημασιν ἡ διαλεκτικη ἡμιν ἐπανω κεισθαι, και ουκετ' αλλο τουτου μαθημα ανωτερω ορθως αν ἐπιτιθεισθαι, αλλ' ἐχειν ηδη τελος τα των μαθηματων; Εμοιγ' ἐφη. (Plato, *Republ.* vi. p. 400, ed. Bekker.)

[4] Το δε κεφαλαιον και το κυρος της Πλατωνος, αἱρεσεως, ἡ περι των νοητων διαταξις. (Atticus Platonic. apud Euseb. *Præp. Evan.* xv. c. 13.)

[5] Τα γαρ ειδη χαιρετω· τερετισματα γαρ εστι. (Aristot. *Anal. Post.* i. c. 22.)

nature of the thing, when we have only explored the philosophical meaning of the term. Thus Aristotle, whilst he rejected the Platonic ideas, still conceived that there were universal principles in nature, in the knowledge of which true science consisted. He differed at the same time essentially from Plato in his view of these universals. Plato regarded the ideas as causes of the *existence* of sensible objects; whereas Aristotle considers the universals of which his philosophy treats, as causes of *our knowledge* of nature. Aristotle did not allow that these universals had in themselves any physical reality independent of the human mind, but he conceived that they pointed to the real internal nature of existing things.

Philosophy, accordingly, under his hands, stripped of its metaphysical mysticism, assumed a logical aspect. The foundations of science were laid in definitions of those essential natures which he conceived to be the substrata of universals; and from these definitions the particular truths of the sciences were to be deduced as a series of consequences.

From this view of the nature of science, it followed that he should employ induction, rather to determine notions, than to arrive at general principles, such as in modern philosophy are denominated Laws of Nature. In order to discover an *universal* principle, on which a system of science might be raised, it was necessary to state exactly that conception of the mind which belonged exclusively to any particular class of objects. The stating such a conception was, in the phraseology of Aristotle, the assigning of the λογος of the ουσια, or the giving a definition of the object as it really existed. A notion of this kind required an accurate analysis of thought. Every notion common to other objects was to be rejected; and after the rejection of these, that which remained exclusively appropriate to the object under consideration, was to be assumed as the proper universal by which its real nature was denoted. The process was not dissimilar to that by which the truths of modern science are elicited, except that the induction of Aristotle terminated in *universals;* whereas the induction of Bacon terminates in *general* principles; —such principles being the utmost that can be obtained from outward observation of objects. It is precisely indeed in this point that the great difference consists between the science of Aristotle and that of Bacon. Aristotle, for example, inquires into the nature of light, and endeavours to define it exactly as it differs from all other natures. This definition is an expression of that universal on which the whole nature of light is conceived to depend. A modern philosopher pursuing the method of Bacon, examines facts concerning it, and, distinguishing those which really belong to it from those which do not, concludes from the remainder some general affirmative respecting it. A modern philosopher often draws a conclusion as to the nature of a thing; as when he infers that light is material, or that the soul is immaterial. But then he does not hold such inferences as universals in the sense of Aristotle, nor does he employ them to interpret the facts of a science. He acquiesces in such conclusions as ultimate principles. He finds, for example, the facts belonging to the falling of bodies on the earth's surface, and to the revolutions of the heavens, coincident in the same general law. He pronounces, therefore, that the principle signified by the term gravity, whatever its nature may be, is the same in both classes of facts. His conclusions at the same time in Natural Philosophy are independent of this assumption, as these would not be affected though the principle of gravitation were proved to be different in the two cases. If you overthrow, on the other hand, a speculative doctrine of the ancient physics, all the conclusions fall to the ground.

We shall wonder the less at the peculiar complexion of Aristotle's philosophy, when we observe that even modern philosophers have been by no means exempt from the realism which language tends to suggest, and which might almost be termed the original sin of the human understanding.

Such, then, according to Aristotle, was the character of philosophy, so far as it was purely theoretic. It furnished the mind with the means of contemplating nature surely and steadily, amidst the variety of phenomena which external objects presented, by fixing it on universal principles, eternal and unchangeable.

But this was not the only view which he took of philosophy. He did not limit it to contemplation alone. He regarded it further as ministering to human life under two other distinct points of view—as it was productive of some effect, and as it instructed us for action. Thus, he distributed philosophy in general into three branches: 1*st*, Theoretic, 2*d*, Efficient, 3*d*, Practical; including under Theoretic, Physics, Mathematics, Theology, or the Prime Philosophy, or the science more familiarly known by the name of Metaphysics; under Efficient, what we commonly term the arts, as Dialectic or Logic, Rhetoric, Poetics; under Practical, the moral sciences, as Ethics and Politics. Whilst, then, in order to a purely theoretic philosophy, he consistently endeavoured to present to the mind the primary elements of thought, attending rather to the order of human reason than to the phenomena of nature, he had a different aim in the two other branches of philosophy, and pursued a different method. In these, his aim was to enable the student to realize some effect, or to attain some good; in Efficient Philosophy, to lay before the mind those principles which constitute the arts; in Practical, those principles by which the goods of human life are attained by individuals or societies. Thus, in both these branches his object was precisely what Bacon's was in the whole method of his philosophy—to increase human power by increasing human knowledge. And he has accordingly adopted, in pursuing them, the same inductive method which Bacon has formally explored in the *Novum Organum*. We find him in these strictly attending to experience—deducing his speculative principles from facts, and pointing out their application to the realities of the arts and of human life. Under the term τεχνη, indeed, which we commonly translate art, he comprised much more than is understood by art. Chemistry, for instance, might justly be referred to this branch of philosophy, so far as its principles are applicable to the production of any effect. In fact, it corresponds more nearly with science, in the acceptation of the word science by Bacon, or to what is commonly understood by the term "applied sciences;" for Aristotle himself expressly asserts it to be the result of experience—observing, that memory of particular events is the foundation of experience, and that from several experiences art is produced.[1]

So also, in his practical philosophy he directs us not to seek a speculative certainty of principles, but to be satisfied with such as result from the experience of human life. He further even cautions us against treating this department in the *a priori* method of his theoretic philosophy, in remarking that the doctrine of universal good was an useless speculation in that kind of inquiry.[2] Had he viewed Natural Philosophy in its application to the

[1] *Metaph.* i. 1; *Analyt. Post.* ii. last chap.

[2] *Mag. Mor.* i. 1; *Eth. Nic.* i. 6.

Aristotle's Philosophy.

arts, he would surely have introduced the inductive method there also; and in truth he has done so, so far as particular departments of nature are explored in his writings in order to particular arts. But his works professedly treating of Natural Philosophy belong to a higher speculation, according to his estimate, than those which concern human life. He conceived the things of the material world to be endued with an unoriginated and indestructible nature, and *therefore* the eternal objects of scientific truth,[1] whilst every thing belonging to man was temporary and variable. The former, therefore, were not satisfactorily investigated until they were referred to their ultimate fixed principles; but of the latter it was sufficient to obtain such knowledge as the contingency of the objects admitted. He perceived, from his accurate and extensive knowledge of human nature, that there was no ground for that realism in morals which the more uniform aspect of the physical world tended to inculcate. The immense variety of objects to which the appellation of "goods" was applied, impressed on his acute mind the conviction, that there was no one fixed and invariable principle implied by that term; and that the philosophy of moral subjects, accordingly, was to be sought simply in an observation of facts, without endeavouring to trace them to some further principle.[2]

It will illustrate this arrangement of the sciences to look to the Theory of Causation, or the classes into which the ancient philosophy distributed the several principles of scientific truth. Now, the classes of such principles assigned by Aristotle are, 1*st*, the Material, or that class which comprehends all those cases in which the inquiry is, *out of* what a given effect has originated. From the analogy which this class has to the wood, or stone, or any actual material, out of which any work of nature or art is produced, the name "material" has been currently given to the class. But it is not commonly so termed by Aristotle, whose description of it is more precise and philosophical.[3] Unfortunately, the adoption of the term "material" has been the source of great misunderstanding of Aristotle's doctrine. It has been supposed to imply that inquiries coming under this head refer to something physically existing, some real object, as wood or stone; whereas, according to Aristotle, it is simply a view of antecedents, that is, of those principles whose priority is implied in any given fact.[4] The material cause, then, is properly an intellectual class of principles—one method of analysis, by which the mind simplifies to its own view the variety of existing objects.

The second class of causes is that to which all inquiries belong, which respect the proper characteristic nature of a thing. To this Aristotle gives the name of ειδος, form or exemplar.[5] It corresponds with what are termed in modern philosophy "laws of nature." According to Aristotle, and to the spirit of the ancient philosophy in general, it is the abstract essence or being of a thing,—that primary nature of it on which all its properties might be conceived to depend. Bacon, indeed, has retained the scholastic name "form" in his philosophy, and applied it to denote the generalizations of his philosophy;[6]—a general fact, from its excluding all merely accidental circumstances, being in a manner the proper *form* of the particular facts from which it is deduced.

The third class of causes comprehends all inquiries into the motive or efficient principles of a thing. It differs from the material cause—which it resembles so far as it is an investigation of antecedents—in its reference to such antecedents only as are the means in order to an effect. We may contemplate a given effect *as such*, and not simply as a mere *event;* and in that case should inquire into the power by which it was produced, or the Motive Cause. It is to this class that the term cause[7] is popularly applied, by analogy from the works of human art, in which we are able to discern the connection between means and results. Aristotle, however, did not suppose that we could discern any such connection in nature; not intending more by this class than those principles of the mind under which all effects, *as such*, might be arranged.

The fourth class in the ancient theory of Causation is, what in the language of the schoolmen has obtained the appellation of the Final Cause, or, to express it more after the mind of Aristotle, inquiries directed to the perfect nature or tendency of any existing thing. For example, when we appeal from virtue militant in the world to virtue triumphant in heaven, and derive precepts of duty from this ultimate view of virtue, or of the end to which it is tending, we argue from a final cause in the sense of Aristotle: so, again, when it is contended that the eye was formed for seeing, because its nature is perfected in the act of seeing; or, in general, whenever it is inferred that such is the nature of a thing, because it is *best* that it should be so. According to modern views, design is always implied in a final cause. In Aristotle, it is a philosophical view of an intrinsic tendency in nature, analogous to the effect of design.

The division of philosophy adopted by Aristotle corresponds with this division of causes. Physical science, as concerned about objects, of which one appears the result of another, or rather of which one is found to be produced after another, is an investigation of material causes. The inquiry is into the law of that continuation and succession observed in the natural world,—what the antecedents are in this course,—what the ultimate principles, to which the mind may carry its analysis of the succession of natural events.

Metaphysics and mathematics, as employed about notions of the mind, are sciences belonging to the Formal Cause. They endeavour to draw forth that secret philosophy by which the mind administers the world of its own ideas; and, in this process, to arrive at those ultimate abstractions, into which all other principles may be resolved, as into their ultimate forms; metaphysics and mathematics differing only so far as mathematics consider ideas of quantity exclusively, whereas metaphysics embrace all our abstract notions.

Dialectic and the arts in general are inquiries into motive causes, since it is by the arts that human power is exerted in producing certain effects. The principles of rhetoric, for instance, are the means by which the effect of persuasion is produced. In order to produce any effect, we must observe what acts, what moves, what influences—

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[1] *Analyt. Post.* i. c. 8; *Ethic. Nic.* vi. 7.

[2] He has been, on this account, very inadvertently accused by Brucker (*Hist. Cr. Phil.* vol. i. p. 835) of scepticism in morals, instead of being commended for his truly philosophical view of the science.

[3] *Nat. Ausc.* ii. c. 3. το εξ ου γινεται τι ενυπαρχοντος, ii. c. 7. *Analyt. Post.* ii. c. 11, p. 170, Du Val. το τινων οντων αναγκη τουτ' ειναι.

[4] The premises of a syllogism accordingly are the material cause of the conclusion.

[5] Thus he terms it also παραδειγμα, *Nat. Ausc.* ii. 2, Du Val. i. p. 330, the pattern, as it were, of the thing, or its archetype, in the mind.

[6] Bacon, *Nov. Org.* ii. 2.

[7] The word *cause* is indeed, as has been often pointed out, only a verbal generalization of the different principles to which it is here applied. The Greek word αιτιον is nearer the truth.

Theoretic Philosophy.

not simply what precedes or follows—in the course of nature; and a study of this kind constitutes what Aristotle calls efficient philosophy.

The final cause is the science of human actions, or practical philosophy. Actions, being the exertions of inward principles towards some end, cannot rightly be judged of as to their nature, by the view of them merely as effects, but must be considered in their *tendency*. A compassionate action, for example, may in its actual effect be productive of evil; but we cannot estimate the nature of the action from this result, but must further inquire whether the result was coincident or not with the effect intended; that is, we must inquire into its final cause.[1]

But though this is the appropriate classification of the principles of the several sciences, it does not follow that any particular science is restricted to one particular mode of speculation.[2] The several kinds of causes are all employed as modes of analysis under the same head of philosophy.[3] As all philosophy indeed ultimately refers to the principles of the human mind, so far every science is a speculation of the formal cause. In Aristotle's system of physics, the doctrine of final causes occupies in fact the *principal* place, instead of being employed, as in modern philosophy, in subordination to the inquiry into the material cause.

Theoretic Philosophy.

Physics, Mathematics, Metaphysics.

In proceeding to examine in detail the several sciences included in this threefold division of philosophy, and contained in the extant writings of Aristotle, those which he has classed under the head of theoretic philosophy, as being the only *proper sciences* in his view, naturally come first to be considered. These, as we have observed, are physics, metaphysics, and mathematics.

There is the less occasion for considering these three sciences distinctly, as Aristotle in his treatises of them has not strictly maintained their separation, but has often blended their different principles in the same discussion. In this department of philosophy, he receded less from the dialectical system of Plato, and felt the influence of that system attracting him into its vortex. As Plato, by drawing off the attention of the philosophical inquirer from nature itself to the ideas of his intellectual world, was led to confound all the sciences in one philosophical reverie; so Aristotle, in the theoretic branch of his philosophy, looking to the ultimate principles of the sciences as they exist in the human mind, rather than to the phenomena of each, overlooked their real differences in his mode of treating them. The ground of this promiscuous discussion is to be found in that classification which he adopts of the objects of these three sciences.[4] They are all, in his view, conversant about *τα οντα*, or things that ARE; differing in the mode in which they abstract the notion of BEING from existing things. The science which considers Being in union with matter, or as it is evidenced under those variations which the material world presents, is physics. That which considers Being as it is conceived separate from the variations of the material world, though not (probably, he observes) abstracted from matter, is mathematics. Lastly, that to which the name of metaphysics has been given by his commentators, but to which Aristotle himself assigns the name of theology, or the First philosophy, is the science which considers Being separated both from the variations of the material world and altogether from matter. It appears, therefore, that the objects of his inquiry in each of these three sciences were ultimately the same. He is engaged in all—in investigating those universal principles under which he conceives all existing things are arranged by the mind. For this is the meaning of Being in his philosophy. It stands for any of those conceptions of the mind by which the various natures or properties of existing things are denoted. The sciences, accordingly, not differing fundamentally in his view, he was naturally, though very erroneously, led to combine them in speculation.

Hence the abortive and futile character of his physical philosophy. Instead of looking to the phenomena of the material world, he was employed in deducing consequences from metaphysical and mathematical data; arguing from the mere abstract notions of the mind to the realities of external nature. Thus, instead of being an investigation of the laws of nature, it was an airy fabric of speculative reasoning from assumed principles. Whilst he thought that he was delivering incontrovertible truths of physical science, he was only analyzing the connections of the notions of the human mind, and arranging them under their appropriate terms. No other method, indeed, is open to the philosopher, who would penetrate the veil of the actual phenomena, and establish a certainty of science beyond the concessions of nature, but to resort to abstract definitions. These being once laid down, the truths of science follow by necessary connection; for they are then the mere development of general assertions into the particulars implied in them. But, as it thus appears, the certainty and necessity of the conclusions are simply the consistency with our original meaning. It is absurd to suppose them otherwise, because this would be equivalent to asserting that our meaning was not what we asserted it to be. Aristotle indeed himself allows, that truth of fact and truth of science are not mutually implied in each other. "Impossible and possible, and falsehood and truth," he observes, "are either hypothetical—as it is impossible for a triangle to have two right angles if this is so, and the diameter of a square is commensurate with its side if this is so—or absolute. But absolute falsehood and absolute impossibility are not the same; since, for one not standing to say he is standing, is false, but not impossible; and for a harper not singing to say he is singing, is false but not impossible; but to stand and sit at once, or for the diameter to be commensurate, is not only false, but impossible."[5] Still he perversely sought to unite both kinds of truth in his physical inquiries; and in the vain attempt, lost sight of the absolute truth contained in the facts presented to his observation.

The first portion of his physical philosophy, contained in the treatise entitled *Natural Auscultations*, is devoted to inquiries into the principles of the science; in order to ascertain those fundamental conceptions of the several objects of the science, from which all conclusions concern-

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[1] The same principle applies to the arts also, so far as the skill in any art is exerted in action. We then judge of the art so exemplified by its tendency to produce the proper effect; of the wisdom, for instance, of the politician by the adaptation of his counsels to the welfare of his country—not simply by their result, which may accidentally be untoward.

[2] *Nat. Ausc.* ii. 7, *επει δε αιτιαι τεσσαρες, περι πασων τη φυσικη ειδεναι· και εις πασας αναγων το δια τι, αποδωσει, φυσικως, την ὑλην, το ειδος, το κινησαν, το ὑ ἑνεκα. ερχεται δε τα τρια εις το ἑν πολλακις· κ. τ. λ.*

[3] Thus an action may be analysed into the affection exerted in it (the material or physical cause), the moral choice of the agent (the motive cause), the end to which it tends (the final cause), the definition of the virtue to which it belongs (the formal cause); and yet the science of the action is fundamentally an inquiry into the final cause.

[4] *Metaph.* vi. 1, and xiii. chap. 1, 3, and 4. See also *Nat. Ausc.* ii. c. 2.

[5] *De Cœlo*, i. 12, p. 449, Du Val. Also *Metaph.* xiii. 5; and v. c. 12.

ing them were, in the *a priori* spirit of his physical philosophy, to be deduced. Agreeably to this order of inquiry, he sets out with discussing the question, whether these principles should be ultimately referred to one or more than one, and laying down his own doctrine of three principles, to which he gives the denomination of, 1. matter, 2. form, 3. privation. These are the well-known principles, of which so perverse a use has been made by the schoolmen, and which have consequently occasioned much undue censure of the Aristotelian system of physics. That system, indeed, is sufficiently condemned in its *a priori* character, but is guiltless of the absurdity which the scholastic refinements have cast upon it. These three principles are nothing more than general conceptions of the mind, as it endeavours to class the various objects of the sensible universe, and to refer the succession of events without itself to some ultimate unchanging views within itself. It has been already explained what is meant by a material cause, the εξ οὑ or ὑλη of Aristotle. These principles, then, are only different modifications of this cause. They are antecedents, or notions at which the mind ultimately arrives, in an analysis of its complex notions of natural objects; and therefore antecedents, because they must be presupposed in every contemplation of the natural world. The terms by which they are denoted are merely analogical. Aristotle, proceeding on a principle of the Pythagorean school,—indeed the common doctrine of philosophers before him,[1]—argues that, as contraries cannot generate contraries, there must be at least two opposite classes of principles. In the changes observed in the course of the world, one object is succeeded by another; something has passed away, something is produced. Two fundamental notions, therefore, are involved in every contemplation of nature, and these are expressed by the terms Form and Privation; imperfectly characterizing these subtile abstractions, though shadowing them out justly, so far as the relation denoted corresponds with that between the present form of any material object and the previous forms now superseded by it. For example, a statue is a form now constituted in the stead of that infinite multiplicity of figures of which the marble or brass in its unmoulded state was susceptible, and of which it is, as it were, "deprived," in the very act of producing the statue. The very analogy, however, is apt to induce us to suppose that there is something real implied by the terms form and privation in the language of Aristotle. Hence the ridicule with which the statement of privation as a physical principle is commonly received. But if rightly understood, it holds a just and important place in the physical philosophy of Aristotle; and to see the proper nature of it, it should be observed, that it applies no less to immaterial objects than to material.[2] For instance, if we look at man physically, we observe that he is capable of moral improvement. Supposing him, then, civilized and improved beyond his ordinary state, we perceive in such a case a transition from a state of barbarism to a state of culture. The state of culture, then, is the form of which Aristotle speaks; the state of barbarism, which may be in infinite varieties of form, the privation. Or, a person becomes healthy from being diseased: health is the form superinduced, the privation is of every species of disease. But besides those principles which are excluded in the physical constitution of any thing, and so referred to the head of privation,—and those principles in which the peculiar constitution of the thing is found to consist, and which are therefore referred to the head of form,—there are evidently other principles which remain the same in all variations of form. The actual nature of the physical objects remains unchanged: and the notion, therefore, by which that nature is represented to the human mind, must be respected, in assigning a cause for the physical constitution of a thing; as being an antecedent out of which it proceeded. To this notion, or class of principles by which the ultimate common nature of different objects is denoted, Aristotle applies the name of ὑλη, or matter; this notion being analogous to the stuff or substance of which different works of human art are constructed, as marble or brass is the material of which different statues are made.[3]

Now, beyond these it is impossible to proceed in the philosophy of physical existence. They comprise, in fact, the whole of modern investigations in physics, though these last have been prosecuted in an order exactly the reverse of that of Aristotle. These have ended where he began: but they have had these several principles in view. That *abscissio infiniti*, prosecuted in the inductive method of philosophy, is analogous to the "privation" of Aristotle's system. It is a continued process of separating from any subject under examination, of those natures or principles which do not constitute the proper nature of the subject, and thus gradually narrowing the inquiry more and more, until we have at last obtained some ultimate fact, the proper nature of the thing. This ultimate fact, accordingly, Bacon terms the form of the thing, adopting that expression to denote the law or principle by which it exists. It is the result, we observe, which remains to be affirmed, after rejecting and excluding other principles; or, to speak in analogical language, after the subject has been deprived of all those forms in which its proper nature does not consist. Again, Bacon directs that a collection be made of all those "*instantiæ*," instances, to which the form in question seems to belong. These instances, so far as they agree in this respect, correspond with the material principle of Aristotle. They exhibit that common nature, in some one form of which the particular nature sought must be found.

Aristotle, of course, did not conceive of these principles according to the view of them here given. The design of his inquiry is, by an analysis of nature, as that term is applied in physics, to obtain those fundamental notions to which all the various notions involved in the speculation of nature might ultimately be referred. For he explains things that have their being by nature to be such as have in themselves a principle of motion and rest, as contrasted with works of art, the principle of which is in the artist.[4] Aristotle's object, accordingly, is to examine this inherent principle of motion and rest, which is the nature of a thing, and to show how it operates in producing the various forms observed in the world around us. His error was not unlike that of one who should profess to give an account of visible objects solely from what they *appear* to the eye, and who should accordingly describe such objects as flat surfaces, variously shaded and coloured. From this view of the object of natural philosophy, he was led to account for the processes of generation and corruption, and the changes which occur in bodies by alteration, increase and decrease, local motion, mixture. Consequently, he states his ultimate principles of matter, form, and priva-

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[1] *Nat. Ausc.* i 6, p. 322, Du Val.

[2] *Metaph.* vii. 7 and 11; xiv. c. 8; ὁσα αριθμῳ πολλα, ὑλην εχει, p. 1003, Du Val.

[3] *Nat. Ausc.* i. 8, Ἡ δε ὑποκειμενη φυσις, επιστητη κατα αναλογιαν· ὡς γαρ προς ανδριαντα χαλκος, η προς κλινην ξυλον, η προς το αλλο τι των εχοντων μορφην, ἡ ὑλη και το αμορφον εχει, πριν λαβειν την μορφην· ὑτως αὑτη προς ουσιαν εχει, και το τοδε τι, και το ον.

[4] *Nat. Ausc.* ii. c. 1, ὡς ουσης φυσεως αρχης τινος και αιτιας του κινεισθαι και ηρεμειν, εν ᾧ ὑπαρχει πρωτως καθ' αὑτο, και μη κατα συμβεβηκος. *Metaph.* xiii. c. 1, δια το περι τα εχοντα εν αὑτοις αρχην κινησεως και στασεως τὴν του φυσικου πασαν ειναι πραγματειαν. Also *De Cœlo*, i. c. 2.

tion, as generalizations of those latent processes by which physical effects are produced, rather than as principles by which the investigation of nature must be guided. Hence the perverse application of his physical philosophy in the middle ages to work transmutations in nature. The labours of the alchemists were nothing else but a practical realism founded on the intellectual principles of the philosopher.[1]

The discovery of the principle to which the denomination of form is assigned, is, in Aristotle's system, as in Bacon's, the ultimate point of physical inquiry. The investigation of the principles of matter and privation is in order to the discovery of the form; which is thus the τελος or completion of the process of nature. That principle of self-motion which, according to Aristotle, is the object of physics, is then traced to its effect on the thing produced, and we have obtained the ουσια[2] or proper being of the thing.

From this view of the principle of form, as the result of a self-working power in nature, results the peculiar character of Aristotle's physical philosophy. He thought it evident, from such facts as the provident care shown by spiders, ants, and other animals, and the service of the leaves of plants in protecting the fruit, that nature intrinsically possessed this power of working certain ends.[3] The form, then, of every physical object being the attainment of such an end, and the form also constituting the being or nature of the object, occasion was furnished for speculating *a priori* from the supposed perfection, or view of what was best, in any thing, to the form or law in which its nature consisted. This mode of speculation was embodied in those maxims of ancient philosophy, that "nature does nothing in vain;" that "nature always works the best that the case admits;" that "nothing by nature is imperfect."[4] The consequence was, that the very point to be ultimately investigated was assumed at the outset of the inquiry, and all the subsequent steps were merely hypothetical. And thus it is that Aristotle expressly asserts the necessity which belongs to physical facts to be hypothetical—dependent, that is, on the assumption of the end pursued by nature, in like manner as the conclusions in mathematics are dependent on the assumption of definitions.[5]

It is curious to observe the traces of such a doctrine in different systems of philosophy, as they appear under different modifications. In some of the older theories, we find indications of it in the hypothesis of two opposing principles, as love and enmity, by which it was proposed to solve those appearances in nature which were adverse to the notion of the tendency of nature to the best. In the systems of Parmenides and of Hesiod, love and desire—in that of Anaxagoras, intellect—were the expressions of this tendency. In the philosophy of Plato, it was evidenced in the rejection of the material world from the class of permanent and real existences; this doctrine being a ready transition from the notion, which attributed the physical constitution of things to their dependence on some ultimate principles. Modern deists have argued in the same way, when they have rejected an account of things alleged to have proceeded from the Author of nature, because these things did not correspond with what they had determined to be "best" in nature.[6] In Aristotle, on the contrary, it was shown in the opinion of the eternity of the material world; for the perfection of nature consisting in those ultimate forms to which it is tending, the existence of the material world has been always necessary as a condition in order to the end.[7]

The great doctrine of the ancient physics, that "nothing could be produced out of nothing,"[8] required no distinct consideration according to the theory of Aristotle. Inquiring into nature simply as a principle of motion, he was only called upon to show how those changes which took place in the material world might be satisfactorily accounted for. It was no part of his philosophy to demonstrate that any particular material, or combination of materials, was employed in the laboratory of nature for effecting her productions and transmutations. All he assumes is, that some material or other is employed in every instance of a physical object, to effect that perfect constitution of it in which its "form" consists. It is not indeed a physical object, unless it is conceived in conjunction with "matter;" but provided it has "matter,"—that is, has a nature capable of affecting the external senses,—what particular kind of matter it may have, is irrelevant to his inquiry.[9] For example, whether water or air must pre-exist in the production of ether, is not the point with which he is concerned. It is enough that there is in every physical effect a principle of motion operating. It follows, from the existence of such a principle, that there must be some "matter;" otherwise the *material* effect—the effect cognizable by the senses—would not have been produced.

The analogous inquiry in his system is, which are the *prior* principles in the order of transition, so that from the presence or absence of these the constitution of any particular body results? What are those which never pass into each other, and which may therefore be regarded as elementary principles of motion?

Hence his detailed investigation of Motion, considered in the technical sense in which the term is employed in his philosophy, as it is exhibited in physical changes of place, or quantity, or quality; generation and corruption; the action and passion of bodies; and mixture. Hence also his discussion in his physics of questions which, in modern philosophy, are more properly regarded as the province of the metaphysician; as the nature of infinity, time, and place: all which, however, belong to his inquiry, as implied in the various processes of motion.

A speculative difficulty, however, occurred to him in the prosecution of this physical theory, like that which perplexed the material philosophers in respect to the pre-existence of matter. He had to account for the production by motion of a form not previously existing.[10] This he explained by the subtile distinction between potential and actual being. This, in fact, is his analysis of motion. He states it to be an exertion in act of that intrinsic efficacy which is in a thing to produce a particular form.

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[1] The doctrine of transubstantiation is wholly built on, and maintained by, an Aristotelian philosophy of this kind. The remark will readily be extended to other refinements of scholastic theology.

[2] Hence, he observes, the term *nature* is metaphorically applied to denote the being, ουσια, of any thing. (*Metaph.* v. c. 4.)

[3] *Nat. Ausc.* ii. c. 8, Μαλιστα δε φανερον επι των ζωων κ. τ. λ. *De Anim.* iii. c. 12, Ἑνεκα του γαρ ἁπαντα ὑπαρχει τῃ φυσει, η συμπτωματα εσται των ἑνεκα του. *Polit.* i. 1, οἷον γαρ ἑκαστον εστι, της γενεσεως τελεσθεισης, ταυτην φαμεν την φυσιν ειναι ἑκαστου, ὡσπερ ανθρωπου, ἱππου, οικιας.

[4] *De Anim.* iii. cap. 10 and 12; *De Cœlo*, i. cap. 4, and ii. cap. 5, 8, 11; *De Gen. et Cor.* ii. c. 10; *Polit.* i. cap. 1, 5.

[5] *Nat. Ausc.* ii. cap. 9.

[6] See Bishop Butler's *Analogy*. Introd. p. 9; also *Origen. con. Cels.* ii. p. 102, ed. Cantab.

[7] In *Cœl.*, ii. cap. 1, he speaks of the eternity of the universe as the only opinion consistent: τῃ μαντικῃ τῃ περι τον θεον.

[8] *Metaph.* xiii. cap. 6, Το γαρ μηδεν εκ μη οντος γενεσθαι παν δ' εξ οντος, σχεδον ἁπαντων εστι κοινον δογμα των περι φυσεως. Also *Nat. Ausc.* i. cap. 5.

[9] *De Gen. et Cor.* i. cap. 3, Το δη ταυτα, η τοιαυτα ἑτερα ὑποτιθεσθαι, διαφερει ουδεν· τον γαρ τροπον ζητουμεν, αλλ' ου το ὑποκειμενον.

[10] *Nat. Ausc.* iii.; *De Gen et Cor.* i. cap. 3.

He considers this power of working ends in nature, as analogous to the skill of a physician[1] working his own cure. Nature, which is thus in his view as an animation or life[2] of all existing things, realizes in herself those principles, which were previously inherent in her constitution, and are then *developed*, when an actual effect is found to take place. Nothing, therefore, is produced, in his system, which was not before in existence. What already existed potentially, is simply produced into actual being, and manifested to our perception in some physical object.[3] To describe it in terms of modern philosophy, we should say it was a transition from metaphysical existence to physical; from an object of the mind only, cognizable by the internal principles of our constitution, to an object of the external senses;—the mind perceiving the principle of motion *as a principle*,—the senses giving us the primary impression of the principle *moving* or operating on matter.

This doctrine of potential being, transmitted through the scholastic philosophy, and through that perverted to realism, has given occasion to represent a coincidence on this point in the system of Aristotle with the ideal theory of Plato, the very part of Plato's philosophy which Aristotle most directly opposed. But it should be observed, that the forms of which Aristotle speaks, are not, like the ideas of Plato, constituent of physical objects. They are the philosophy of nature considered as an instinctive principle of motion—general principles under which the mind classes the operations of physical power, analogously to its own external operations.

Leaving, then, the question as to the material itself, of which physical objects are composed, untouched, Aristotle examines what principles reject and exclude one another in the various changes of the material world. For these are the causes of the transitions of one nature into another, and of generation and corruption: the presence of one involving the privation of all those forms of matter dependent on the presence of the other. What these mutually excluding principles are, he decides by a reference to the sense of touch; that being the proper evidence to us of the existence of body: since, though sight may give us the first notices of the *existence* of a material thing, it does not inform us of the *material* nature of the thing; which we infer from the resistance to the sense of touch. Accordingly, Aristotle explains what is sensible to be what is tangible.[4] The contrarieties then ascertained by touch, and which account therefore for all the different forms of matter, are hot and cold, dry and moist; the first two as active principles, the last two as passive. The touch, indeed, informs us of other contrarieties, but they are all reducible to these four heads, with the exception of light and heavy. These last are excluded from the class of physical principles; since, though Aristotle, in common with other ancient philosophers, held them to be positive and absolute natures, he found, that they could not act on each other, and therefore could not effect any physical change. As hot and cold cannot co-exist, nor can moist and dry, these four principles admit only of four combinations, and the effect of each combination is a different element. The combination of hot and dry is fire; of hot and moist, air; of cold and dry, earth; of cold and moist, water. Any one of these elements may pass into another[5] by the privation of one of the combined principles: since then, the contrary principle, which had been only excluded by the presence of its contrary, combines with the remaining one; *e. g.* water is transformed into air, by the privation of cold, and the consequent combination of hot with the moist which remains; or both principles combined may be superseded by the two opposites, as when fire and water may be changed into each other. Thus there is a subordination of principles wherever the principle of motion is exerted in act. First, there must be matter, that is, a principle susceptible of the contrarieties; then the contrarieties; and last of all the material elements themselves.[6] When the change effected involves an entire change of the material from which it proceeds, the process is that of generation and corruption; but when the change is simply in the affections of some existing body, as when the same person from being unmusical becomes musical, or the food of an animal is converted into its substance, the process is that of alteration.[7]

Thus does Aristotle account for all the changes which take place in the world immediately about us. Whether we observe things produced altered in their sensible qualities, or in bulk, or in place (and to one or the other of these every physical effect may be inferred), the changes observed may be traced to the operation of a principle which is either one of these four already mentioned, or some modification of them; for all the intermediate principles between two contrarieties are to be regarded as contrary, and capable therefore of effecting physical changes in the same manner as the extremes.

But the changes which occur immediately in the world around us, constituted, in the view of the ancient philosopher, a very inferior part of the objects of physical science. The luminaries of the celestial world were regarded by Aristotle as superior to man himself, and the study of their laws as a higher employment of the intellect than the philosophy of human life.[8] Besides, however, the intrinsic excellence of this branch of physics, it demanded his attention from its necessary connection with the full development of his theory of motion. All the other physical changes, it appears, imply local change, which may therefore be inferred to be prior to every other.[9] Further, to keep up the constant succession of generation and corruption which is carried on in the world, there must be some principle ever in actual being; and the revolution of the heavenly bodies continuing incessantly, exhibits a principle of local motion adequate to this effect. Aristotle, accordingly, was led to philosophize on the motions of the heavens, in order to trace up the propagation of motion in this lower world, through its successive impulses, to the prime mover. This being discovered, his philosophy of nature is then completed, since nature is then fully explored according to his analysis as a principle of motion and rest.

His whole astronomy is dependent on those speculative notions which he had adopted, of lightness and heaviness, as intrinsic and absolute properties of bodies. He considers lightness the same as positive tendency upwards, and heaviness as positive tendency downwards. But this view implied that there were certain fixed points, the extremes to which these qualities of bodies tended, and in which they naturally rested as they naturally possessed either lightness or heaviness. Each of the material ele-

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[1] *Nat. Ausc.* ii. cap. 8, Μαλιστα δε δηλον, οταν τις ιατρευη αυτος εαυτον· τουτῳ γαρ εοικεν ἡ φυσις.
[2] *Ibid.* viii. cap. 1, Οιον ζωη τις ουσα τοις φυσει συνεστωσι πασιν.
[3] *Ibid.* viii. cap. 14. Du Val, vol. i. p. 414.
[4] *De Gen. et Cor.* ii. c. 2.
[5] *Ibid.* ii. c. 4.
[6] *Ibid.* ii. c. 1, ἡμεις δε φαμεν ὑλην τινα των σωματων των αισθητων, αλλα ταυτην ου χωριστην, αλλ' αει μετ' εναντιωσεως, κ. τ. λ.
[7] *Ibid.* i. c. 4.
[8] *Eth. Nic.* vi. c. 7.
[9] *Metaph.* iii. c. 2, p. 860; *Mag. Mor.* i. c. 35.

ments, accordingly, had its proper place in the universe, corresponding to the degree of lightness or heaviness which he conceived them to possess, absolutely in themselves, and relatively to each other. Fire he placed in the extreme point upwards, earth in the lowest; air next to fire, and water next to earth. Each of these elements, therefore, he argued, as naturally tending either upwards or downwards, moved in a straight line, and could not consequently move *naturally* in a circle. Hence the earth must be at rest, and therefore be the centre of the universe. For if it revolved round the sun, as the Pythagoreans thought, it would be moving unnaturally, and therefore could not move eternally. Hence, also, no revolving body could consist of any of the four material elements. It must be some other material, to which circular motion was as natural, as rectilineal motion is to earth or fire.

On the ground of such speculative notions Aristotle proceeded in constructing his system of the universe; in opposition to the more enlightened researches of the Pythagorean astronomy, and the records of Egyptian and Babylonian[1] observations on the heavens. In some instances, indeed, his view was more correct. He admits the spherical[2] form of the earth, from the evidence of lunar eclipses, in which he had remarked that it always exhibits a curved outline; and infers its magnitude to be not very great,[3] from the variation of horizon consequent on a little variation of our position on its surface.[4] But, in acknowledging these facts, he was influenced by their accordance with his speculations *a priori*, as he rejected or misinterpreted other facts from their repugnance to these speculations. For the spherical form of the earth resulted from his theory of gravity. It was the effect of the tendency of all the particles of the earth to the lowest point; this lowest point being a centre of the two opposite hemispheres of the heavens. For, that the whole heavens were spherical, he supposed a necessary consequence of the perfection belonging to them, a solid being the most perfect mathematical dimension. The tendency, consequently, of all the particles of the earth to the lowest point, was a tendency towards a middle; or this lowest point would be a centre round which the earth would adjust itself in a spherical mass.

The reason assigned by Aristotle for the revolutions of the heavens, as appears, then, is precisely opposite to that of modern philosophy. He conceived revolution to be performed, not in consequence of a tendency to the centre, but of the absence of any such tendency in the revolving body. Revolution and gravity are, according to him, contradictory terms. The motions of the several heavenly bodies result from their being carried round by spheres, which consist of this revolving element. That they do not revolve in themselves he considers to be evident from the fact that the moon always presents the same side towards us.[5] They are incapable indeed of motion in themselves, he argues, in being spherical, nature seeming purposely to have denied them all power of motion in giving them the form least apt for motion.[6] They revolve, therefore, from being bound in revolving spheres, the first in order of which is that in which the fixed stars are placed, and then the several planets, five in number, the sun, and next to the earth the moon;[7] and to account for the apparent irregularities in the motions of the heavenly bodies, he supposes, following the theory of Eudoxus,[8] that there were as many additional spheres employed in the revolutions of each body as it appeared to have different motions.

The oblique motion of the sun, viewed in connection with the successive renewals and decays of nature, as he approaches or recedes from the earth, suggested the most ready link for connecting the phenomena of the earth with those of the heavens. It is, accordingly, to the revolution of the sphere of the sun, that Aristotle ascribes the continuation of generation and corruption in unbroken series, and the consequent perpetuity of being in the world around us. It might be supposed that generation and corruption would be carried on at equal intervals: but the unequal temperament of material things prevents such a uniformity; and occasions that variety of duration, which we observe in different things within the sphere of the moon, or the limits of nature properly so called.[9]

Still, however, it remained to be explained what it was that imparted to the sphere of the sun, as well as to the several other spheres, their principle of motion. To every thing that is itself moved there must be a mover: and the successive motions, therefore, as communicated from sphere to sphere, must be traced up to some ultimate principle, itself unmoved, in which they originate.

Here, then, we discern the close connection of Aristotle's physics with his metaphysics; and at the same time the ground of his applying to the latter science the designation of theology. The several spheres of the heavens, differing in element from the bodies of this lower world, and pursuing their unceasing and immortal revolutions, presented a distinct class of ουσιαι, beings, or substances, to the speculation of the philosopher. To ascertain that in which they moved and had their being, was an inquiry, with regard to them, analogous to his investigation of the principle of motion in the natural world. This principle of motion to these celestial substances would be being itself, or the very vital energy itself in which they had their being.[10] At the same time, in exploring this primary being, he would be tracing those general principles, by which the mind held together the various objects of physical contemplation, to one ultimate law or master-principle, in which, as in a single theorem, all the truths of science should be comprised.[11]

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[1] *De Cœlo*, ii. 12, παρ' ὧν πολλας πιστεις εχομεν περι εκαστου των αστρων. Also *Metaph.* i. 1. Herodot. *Euterp.* 109.

[2] He speaks of it in *Meteor.* ii. c. 5, p. 562, as shaped like a tympanum.

[3] Mathematicians, he says, had computed its circumference to be 400,000 stades, or about 40,000 miles.

[4] Hence, he observes, "those who supposed the region about the columns of Hercules conjoined with that of India, and the sea to be thus one mass, seem to conceive what is not very incredible, alleging, as they did, in evidence of their conclusion, that elephants were found at both extremities." (*De Cœlo*, ii. 14, p. 471.)

[5] *De Cœlo*, ii. 9.

[6] *Ibid.* ii. 11.

[7] The Pythagoreans connected with this notion the beautiful fancy of the music of the spheres. Aristotle expresses his admiration of the thought, but denies its possibility. The stars move with the spheres, he says, like the parts of a ship with the ship, and therefore can make no sound. (*De Cœlo*, ii. 9.)

[8] *Metaph.* xiv. c. 8. Eudoxus assigned fifty-five spheres on the whole; or, deducting those added to the sun and moon, forty-seven. Aristotle only states this as what may reasonably be thought; leaving, he says, the assertion of its necessity to others more confident, ισχυροτεροις, than himself, p. 1003, Du Val. Eudoxus of Cnidus went into Egypt about 368 B. C. and introduced the regular astronomy from Egypt into Greece. Aristotle gives him the high praise of recommending his view of pleasure as the chief good, by the distinguished morality of his life. (*Eth. Nic.* x. 2.)

[9] *De Gen. et Cor.* ii. c. 10.

[10] *Nat. Ausc.* viii. c. 4, 5, 6, 8; *De Cœlo*, i. c. 9; *Metaph.* xiv. c. 6 and 7.

[11] *Metaph.* iii. 2, ἡ μεν γαρ αρχικωτατη, και ἡγεμονικωτατη, και ἡ ὡσπερ δουλας ουδ' αντειπειν τας αλλας επιστημας δικαιον, ἡ του τελους και τἀγαθου τοιαυτη.

Theoretic Philosophy.

This intimate connection of theology with metaphysics, in the ancient philosophy, was a natural consequence of the separation which heathenism established between theology and religion. In the civilized states of antiquity, religion was pursued only as a matter of policy, and not as a rule of life to the individual. Whatever was the established creed of the state, it was the recognized duty of the good citizen to support as established.[1] Not involving any question of truth or falsehood in the particular creed adopted, it readily admitted of any additions of superstition not repugnant to the laws and manners of the state, but imperiously rejected all questioning of the principle itself, that the established religion must be practically adopted.[2] It may be said to have been the great principle of their religion, that it should be no question of truth and falsehood. The religious feelings of the human heart were thus unnerved. Their strength was spent in showy pomps or cumbrous ceremonies, if they were not corrupted by demoralizing orgies. In this state of things, the better and wiser part of men were driven into a metaphysical religion. They could not acquiesce in the views of the Deity conveyed in the popular superstitions; and the subject could not but recur to them in the reasonings of their hearts, as soliciting earnest inquiry. They searched for God, accordingly, not seeking what to *do*, but what to *know*. Whatever the truth concerning him might be, it was not to be expressed in any acts of adoration. Though the whole world might be found his temple, he was not to be the Holiness of their shrines. Though the heavens were telling of his glory, and the stars were singing together for joy at his presence, yet no praise was to ascend to him in the perfumes of their altars, or the melodies of their choral hymns. Thus, devotion being banished from the heart, reared a tabernacle for itself in the wilderness of a theological philosophy; and thus Socrates and Plato, and Aristotle and Cicero, and other illuminated sages of heathenism, continued, without hypocrisy, professors of the established religion, whilst they sought a purer knowledge of God in the thoughtful abstractions of their own intellect.

Looking, then, at the admirable order of the heavenly bodies, the philosopher saw, in their unvarying regularity, the immutable and eternal nature of the great principle on which their motions depended. He did not, it seems, attribute to them a proper divinity in themselves; for he refers their perpetuity of motion to the ultimate principle or First Mover, the Deity of his system. But he speaks as if they possessed a divine nature, calling them divine bodies, and applying to them the term αιωνες or *æons;* which name, he says, was uttered by the ancients with a divine meaning.[3] He also says expressly that we must think of them as partaking of life and action. He must be supposed, however, by such expressions, to be giving only an analogical description of the perfection, in which they display the efficacy of the First Great Principle. Contrasted with the unstable things of the earth, they evidence the principle of motion perpetually operating without interruption; whereas the successions of generations and corruptions about the earth only approximate to the unbroken perpetuity of the heavenly motions. We ought indeed to interpret in the same manner his ascription of power to nature as a principle of motion. It seems as if he was excluding the agency of the Deity; but in truth he is only analyzing one mode of the operation of the First Principle. For he thinks that all things attain the good of their nature, so far as they have something *divine* actuating them. It is this divinity in them which is the primary source of all perceptions of pleasure;[4] the indistinct apprehension of which he supposes to be the motive of exertion in all things that are capable of action, though they may be unconscious of its being so.[5] Hence it has been maintained, that the doctrine of Aristotle differed but little from the pantheism of Spinoza.[6] The operations of nature, then, as well as the revolving spheres of the heavens, are divine, inasmuch as they illustrate more or less perfectly the animating principle of all motion,—the operation of Deity itself. At the same time, it must be observed, there is no notion of the Deity inculcated as the Creator and Governor of the Universe. It is simply as the Life of the Universe—the Intellect—the Energy—as what gives excellence, and perfection, and joy to the whole system—that his philosophy explores the Deity. It is, in short, pure Being, abstracted from all matter, and therefore only negatively defined as without parts or magnitude, impassible, invariable, and eternal. But whilst his system included no providence,[7] it has the merit of excluding the operation of chance and accident. These, he observes, are not capable of being causes of any thing; they are merely descriptions of what takes place contrary to some presupposed design, or some tendency in nature.[8]

In his metaphysics, properly so called, he considers this

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[1] See Xenophon's *Memorab.* iv. c. 4. The great rule of piety inculcated by Socrates is, Νομῳ πολεως. See also Polyb. vi. 56.

[2] In *Topic.* i. 11, Aristotle says that there are some who are not to be argued with; and mentioning such as require punishment rather than argument, he instances in those who question, "whether one ought to honour the gods," p. 187, Du Val. See also *Eudem.* i. c. 3.

[3] *De Cœlo*, i. 9, p. 446, Du Val; και γαρ τουτο τοὐνομα θειως ἐφθεγκται παρα των αρχαιων, κ. τ. λ. *Metaph.* xiv. 8. p. 1003, "It has been handed down by primitive and ancient men, left in the figure of fable, both that these are gods, and that the divinity encompasses universal nature; but all else has been fabulously associated in order to influence with the multitude, and for its use in respect to the laws and expediency. For they say that these are of human form, and like some of the other animals, and other corresponding things, such as those that have been mentioned: Of which accounts should one separately take this only, that they held the first beings to be gods, he might consider it to have been divinely expressed; and as probably each art and philosophy has been often discovered to the utmost and again lost, so also that these their opinions, like relics, have survived up to the present time. Now our hereditary opinion, and that derived from the primitive men, is so far only manifest to us."

[4] *Eth. Nic.* vii. c. 13, παντα γαρ φυσει εχει τι θειον, κ. τ. λ.

[5] *Ibid.* x. 3, ισως δε και εν τοις φαυλοις, κ. τ. λ.; also, *Metaph.* xiv. 7, p. 1000, Du Val; *Polit.* vii. 3, σχολη γαρ αν ὁ θεος εχοι καλως, και πας ὁ κοσμος, κ. τ. λ.; also *De Cœlo*, i. 9. In *De Anim.* i. 3, he substitutes "the Deity," where, according to his usual mode of speaking, he would say "nature," καιτοι γ' εχρην τον θεον, κ. τ. λ. p. 625, Du Val.

[6] See Bayle's *Dict.* article Aristotle.

[7] There is a passage in his *Ethic. Nicom.* x. 8, in which he alludes to the supposition of a divine superintendence, επιμελεια; but he there evidently makes the appeal rhetorically, to recommend that cultivation of the intellect in which he places man's highest happiness. A further evidence of this is, his speaking of *gods* in the plural in that passage. At any rate, the superintendence here spoken of, is distinct from what we mean by providence, as he does not suppose it extended over the bad as well as the good. In his *Magna Moralia*, ii. c. 8 (Du Val, vol. ii. p. 185), he argues that the superintendence and benevolence of the Deity cannot be supposed the same as good fortune, ευτυχια, because it is not reasonable that the Deity should superintend, επιμελεισθαι, over the bad; and we observe the bad sometimes fortunate.

[8] This view of Chance agrees with the remark in Thucydides, that "we are accustomed to charge Fortune with whatever happens παρα λογον, out of the course of reason," book i. chap. 140. Aristotle has expressed the same in his *Rhetoric*, i. c. 5, εστι δε και των παρα λογον αγαθων αιτια τυχη.

First Principle strictly in a metaphysical point of view. His professed object here is, to inquire into "Being so far forth as it is Being, and the general properties belonging to it as such."[1] Having traced the changes which occur about the earth to a fixed principle, he had presented one unchangeable point of view in which the human mind might contemplate the vast and restless variety of physical objects. It remained for him, then, to examine this ultimate principle in itself, and its various applications, or properties, as he describes them, as the foundation of all science.

His employing the term "Being" so definitely, gives the appearance of his being engaged in the investigation of realities here; just as, in his physics, he appears to be describing secret processes of nature rather than philosophizing on the course of nature. Hence we might be induced to think, that in reading the metaphysics of Aristotle we are exploring the mysteries of ontology. The expressions indeed of Aristotle, and perhaps his example in some parts of his metaphysics, afforded occasion to the ontology of the schools. Aristotle, however, is not to be charged with the realism and absurdity of that system. These may be traced chiefly to a circumstance already adverted to—the introduction of Aristotle's philosophy into the western church by the medium of Latin translation. The term ουσια, by which he denotes existence in the abstract, as distinct from any object of which it is affirmed, having been rendered in Latin by *substantia;* it came to be supposed, that the natures or principles represented by the term had a real subsistence. Thus the doctrine of Aristotle respecting Being, was understood in a sense precisely the reverse of that which the philosopher himself intended. The analogy on which the application of the term *substantia* to metaphysical subjects was founded, became obscured by the actual force of the term itself. Instead of its being regarded as denoting only a relation between our conceptions corresponding to that between a thing supported and what supports it, the idea was suggested of a reality, or even of a material nature, as implied by the term.

Rightly, however, to understand Aristotle's notion of Being, as it is the object of metaphysics, we should distinguish between Being, as it is in nature generally, and as it is in the human mind in particular. For it is in this last sense that it must be understood, when it is stated, that Being abstracted from all objects whatsoever, is the object of the universal science: since there is no other sense, in which a Being which is not in any thing can be conceived, but as it is the pure object of intellect, or is in the intellect solely. Looking, then, at nature at large, we must apply Being, in its first and proper sense, to individual objects really existing; and in a secondary sense, to the attributes of such: because, the first notion of Being in nature is suggested by the actual existence of the object; and our next notions result from the operations of our minds about the object already presupposed in existence. But the case is different, when the objects whose being we are considering, are objects of intellect in themselves. Here the abstract notions of things are the first in order:[2] these are, relatively to the mind, the realities about which it is engaged; whereas the actual objects in nature are, in this point of view, the secondary beings. The reason is, that an object of the mind, as such, exists in its proper nature when it is entirely abstracted from all matter, but loses that nature in proportion as it is conceived in any actual form of physical being.

Hence, in the science of metaphysics, the proper if not the only substance, or ουσια, is the form or abstract nature of things.[3] This, as explained by Aristotle, is the exemplar or representation in the mind of a thing as it exists in nature. As, then, the primary substances in nature are the things themselves as they are found and observed in nature, so the primary substances in the world of the mind are those abstract forms by which the truth and reality of things are there shadowed out. The science of metaphysics, then, is strictly conversant about these abstract forms, just as natural philosophy is conversant about external objects of which the senses give us information.

The object, then, of Aristotle in his metaphysics, is to explain the nature of those general principles, by which the mind represents to itself the objects without it as they really are; which principles are thus the foundations of all philosophical truth. Hence, in the technical language of ancient philosophy, he describes this science as the science of First Causes—the First Philosophy—or by the general title of Philosophy. But a science such as this is precisely what modern writers have designated by the Philosophy of the Human Mind, though they have differed from Aristotle in their mode of investigation: they having directed their attention principally to the operations of the mind, whilst he has confined himself, in this department at least of his philosophy, to the objects about which the mind is conversant.

In his inquiry into these principles, Aristotle had to encounter two extremes of opinion maintained by philosophers before him—the doctrine of Protagoras, Empedocles, and others, who held that there was no fixed standard of such principles in nature, but that every thing was relative to human perception; and the ideal theory of Plato, which, by the hypothesis of self-existent universals, introduced a subtile materialism into the philosophy of mind.

He points out the practical absurdity of the former opinion, according to which contradictories were equally true, and every proposition was equally true and equally false—by asking,[4] "why a man walks to Megara, and does not remain still, thinking that he is walking; why he does not step down a well or a precipice, as it may happen, the first thing in the morning, but uses caution, as not equally convinced that the falling in is a good, and not a good?"[5] Again, that men do not regard all notions as equally true, is plain, he observes, from this, that "no one who may have supposed himself during the night at Athens, when he was in Libya, walks to the Odeum."[6] He refutes, however, this sceptical doctrine more expressly, by distinguishing between the reality of things as they exist absolutely or relatively to our perceptions. There may be no reality of Being, either in things perceived or in the perceptions, these being affections of the percipient power. But it is impossible that there should not really exist some subject-things which produce the perception, and are independent of perception. Whereas those who make *being* dependent on perception, by asserting that whatever appears is true, imply that nothing would exist if there were no living creatures.[7] Hence it appears that Aristotle virtually admits the distinction made by

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[1] *Nat. Ausc.* ii. 6, 7, 8; *Metaph.* xiii. 8.

[2] *Metaph.* xiii. c. 4, την δε πρωτην ειρηκαμεν επιστημην τουτων ειναι, καθ' ὁσον οντα τα ὑποκειμενα εστιν, αλλ' ουχ ἡ ἑτερον τι.

[3] *Ibid.* vii. 5.

[4] *Ibid.* iv. c. 4; Du Val, ii. p. 876.

[5] *Ibid.* iv. c. 5.

[6] *Ibid.* iv. 4, 5.

[7] *Ibid.* iv. 5, το μεν ουν μητε τα αισθητα ειναι, μητε τα αισθηματα, ισως αληθες· του γαρ αισθανομενου παθος τουτο εστι· το δε τα ὑποκειμενα μη ειναι ἁ ποιει την αισθησιν, και ανευ αισθησεως, αδυνατον.

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modern metaphysicians between the primary and secondary qualities of matter. He affirms, that whilst we have ideas of things without us which are simply our own perceptions, or acts of the perceiving mind, there must also be some really existing natures without us on which these perceptions are founded.

The ideal theory of Plato tended to the same scepticism as the doctrine of these elder philosophers, but on a different principle. Plato destroyed all the certainty of our knowledge, by fixing the objects of it entirely out of the range of human intellect, and teaching men to abandon nature and experience in the pursuit of imaginary beings—the ideas, or archetypes of the beings of the sensible world. He established in his system other beings separate from nature as the objects of philosophy, whilst his predecessors denied that there were any proper objects founded in nature. But both he and they equally removed all grounds of conviction from the mind of man. Aristotle, accordingly, strenuously combats the doctrine of ideas as adverse to all sound speculation. He loses no opportunity, in the course of his discussions, of alluding to it and refuting it.[1] He considers it as overthrowing all science, by multiplying, instead of reducing to certain definite principles, the variety of the objects of contemplation. "It is like," he says, "any one wishing to reckon, but who, thinking himself unable when he had less, should make more, and then reckon."[2]

The ideal theory was, as we have before remarked, a modification of the Pythagorean theory of numbers, or a mixture of logical and mathematical truth. Hence the importance assigned by Plato to mathematics, as introductory to the philosophy of ideas. The theory of Pythagoras was, it seems, purely mathematical. What he called numbers, appear to have been imaginary limits to which, as to their ultimate ratios, he referred the proportions observed in the universe. Plato proceeded a step further, and endeavoured to realize these ultimate natures by the help of the abstractions of language; but still retained so much of the mathematical conception of them, as to make the science of them dependent on the knowledge of mathematics; describing the objects of mathematics as intermediate to the ideas and sensible objects.[3] Aristotle shows, then, in opposition both to the Pythagoreans and to Plato, that there are no such principles as numbers really existent in nature as primary and constituent elements of things.

There is no point, in fact, on which Aristotle has spoken more plainly and decisively, than on the non-existence of universals. It is to individuals alone that he allows a real existence.[4] He remarks, that when any principle is asserted of several things, it is by analogy; as in fact there are distinct principles in each distinct thing; "for what belongs to each thing, is the principle of whatever belongs to each."[5] Thus, "whilst the universal man is the principle of man, Peleus is the father of Achilles—your own father of yourself." In things generically distinct, as colours and sounds, the principles differ, but are the same by analogy. In things specifically the same, the principles differ, not in species, but as they are distinct in each individual; *e. g.* the matter, the form, and the moving power, are distinct in this and that man; but in the general principle, τῳ καθολου λογῳ, they are the same. So clearly has he laid it down, that none but individuals have a real existence, and that all other beings are relations, or results of the operation of our minds about individuals.

In extending our survey to the several subjects included in the metaphysics of Aristotle, we must remember, that the science of which he is treating had hitherto been blended with logic under the general name of dialectic. It was hardly to be expected, therefore, that Aristotle, in making the separation, should altogether forget the prejudice which had united them. Nor must we wonder, therefore, that much of the work should be employed in discussing the meaning of terms, and in observations addressed rather to the disputant in words, than to the inquirer into the principles of philosophy. But we should be too hasty in judgment, if we condemned such discussions as foreign to the purpose of the metaphysician. The accurate examination of the notions expressed by such terms as being, oneness, sameness, contrariety, power, is illustrative of the connections of our ideas; for these terms are not dependent on the peculiarities of any one language, but are uniform characters of human thought. It is a curious and important inquiry, accordingly, to ascertain that connection of ideas of which these terms are the general expressions; to trace, *e. g.* all the various modes of thought to which we apply the term contrariety, or which we characterize under the general description of qualities.

The inquiry into the mind, considered in itself as a principle of life and thought, forms, as we have already hinted, no part of Aristotle's metaphysics. In his philosophy such an inquiry belongs to physics, since he regards mind as a principle connected with matter. This inquiry he has prosecuted in a Treatise *On the Soul*, and in several smaller treatises *On the Parts and Motions of Animals*, *On Perception*, *On the Duration of Life*, *Youth and Old Age*, *Life and Death*, *Respiration*, *Memory*, *Sleep and Waking*, and *Dreaming*; to which may be added also the book *On Physiognomy*, and his larger work the *Treatise on Animals*, which, though properly a work of natural history, is also illustrative of the nature of Soul, considered as the living principle in all animated beings. In these several works, it may be observed on the whole, there is less of mere speculation, and a more open display of that power of real philosophy, the δυναμις αναλυτικη, which he so eminently possessed. We find him stating and examining facts,[6] drawing from them conclusions in the spirit of a modern inquirer, and at the same time with the severe accuracy of his own method.

The ingenuity of the ancient philosophers was exhausted in attempting to assign the nature of the soul or living principle. There was no one of the elements, except earth, which did not find its advocate in some theory of the soul. It was represented also as a combination of all elements, or as blood, or intrinsic motion, or a harmony and conjunction of contraries. Aristotle, pursuing the system of his physics, wisely avoids endeavouring to refer the soul to any particular class of material objects, explaining the nature of it, as it is an instance of the union of the two principles, matter and form, in a common result. It is an instance of the principle of matter, so far as there must be an organized body susceptible of life in every thing that lives. It is an instance of the principle of form, so far as that nature, in which the life of the creature consists, is perfectly developed in the animated body. His definition,

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[1] *Gen. et Cor.* ii. 9; *Analyt. Post.* i. 8, 19; *Eth. Nic.* i. c. 4; *Metaph.* xii. 4, 5; Atticus apud Euseb. *Præp. Evang.* xv. c. 13; Plutarch adv. *Colotem.*

[2] *Metaph.* i. c. 7, and xi. c. 4.

[3] See Plato *de Repub.* vii.; Aristot. *Metaph.* xii.

[4] *Categ.* c. 5; *Metaph.* vii. c. 13; *Anal. Post.* i. 31.

[5] *Metaph.* xiv. 4 and 5, αρχη γαρ το καθ' εκαστον των καθ' εκαστον.

[6] He speaks of this part of his philosophy as an inquiry; την της ψυχης ἱστοριαν. *De Anim.* i. 1.

accordingly, maintains the distinctness of body and soul[1] as two principles combined, without defining what the soul is in itself. He illustrates their union by the analogy of the eye and the sight.[2] There must be the eye in order to sight; but the eye, though perfect in its structure, is not an eye unless the principle of sight be superadded to it.

Thus, considering the principle of life as distinct from the organized system in which it is evidenced, he proceeds to inquire into its peculiar laws, by examining the mode of its operation. He divides its mode of operation into five classes, according to the objects about which it is exercised. It is, 1*st*, a principle of nutrition, in which respect it is common to vegetables and animals; 2*dly*, of perception; 3*dly*, of appetites and affections; 4*thly*, of intellect; 5*thly*, of locomotion. Wherever there is perception, there are also, he states, appetites and affections;[3] and consequently all these modes of operation of the living principle are evidenced in brutes, with the exception of intellect, which belongs to man exclusively.

His observations on perception are highly important, as tending to show the existence of living powers in animals, distinct from the organs by which those powers are displayed. He affirms that there is always a medium interposed between the perceiving power and the object perceived,—appealing to the sense of sight. Sight, he observes, is not produced by placing the object on the eye, nor yet can be produced by the object itself at a distance, and consequently must result from something intervening between the eye and the object, so as to make an impression from the object on the eye. He mistook, indeed, the nature of this medium, conceiving light to be the active development of the abstract nature of transparency in some body, as in air or water,[4] and not material or capable of motion.[5] But the conclusion itself is just; and it shows that the eye[6] perceives only as an instrument of communication with external objects to an internal power of the soul. The senses which appear to militate with this conclusion are those of touch and taste, which seem to be produced immediately, without any interposed medium. But there is no reason, he argues, to conclude the flesh to be the feeling power in itself[7] because it acts instantaneously; for an artificial membrane spread over the body would produce the like instantaneous effect: and supposing the air to grow all around us, we should in like manner have immediate perception of all objects of sense, and thus appear to have perceptions of sight, and hearing, and smelling, by one sense.

Perception, then, according to Aristotle, is the power of the soul to receive immaterial impressions from material objects, as the wax receives impressions of a seal without the brass or gold of which the seal is made. The impressions thus received he regards as the basis of all our knowledge, insomuch that a creature destitute of perception would be incapable of understanding and learning. Touch[8] is the sense indispensable to existence, and the only one so indispensable. All the other senses, he says, have been added for the good and perfection of the animal—*του ευ ἑνεκα*. The sensations are distinct, however, from the ideas of the mind. The sensations in themselves are never delusive,—the same thing is always sweet or always bitter; but they may be followed by different ideas in different minds. To a sick person, what is naturally sweet may seem bitter, or, from accidental position with respect to the spectator, an object may appear different from what it is; as, for example, the apparent diameter of the sun. To the ideas thus formed immediately from perception, Aristotle gives the name of phantasms; and the power of perception thus modified he calls phantasia or imagination.[9] The delusiveness sometimes attributed to the senses themselves originates in this faculty of imagination consequent on sensation. Together with memory, it constitutes the whole intellectual nature of brutes. In man it furnishes the first notices in order to the operation of his intellect. By the operation of the intellect on these notices the first simple ideas are formed, from which the mind proceeds to its complex and general notions.

In considering the nature of the intellect, Aristotle introduces an important distinction between the mere capacity or faculty of knowledge, and the actual knowledge possessed by the mind; that is, between the intellect and the principles of the intellect. He employs the well-known illustration of "a writing tablet in which nothing is actually written," to distinguish the thinking faculty in itself from the thoughts with which it is furnished. But he does not suppose, as this illustration might suggest, that ideas are objects distinct from the mind itself. Where the object of thought is itself immaterial, as when the mind is reflecting on itself, there, he observes, the thinking power and the object of thought are the same.[10] He conceives, however, that the mind is capable of existing without thinking,[11] and consequently does not resolve the whole understanding of man into consciousness. Hence, according to him, whilst the passive intellect, or the mind as it consists of principles with which the senses have furnished it, perishes, the active intellect, the power itself by which we think, exists in its proper nature when separate, and is immortal and eternal.[12]

It may be perceived, from this view of Aristotle's Theory of the Soul, how far he acknowledged the immortality of man. So far as the nature of man is purely intellectual, he conceived it capable of existing separately from matter, and in some sense divine; but so far as it consisted of affections, which he describes as *λογοι ενυλοι*, principles *in* matter, he regarded it as mortal and necessarily perishable with the body. He pronounces nothing of the nature of that immortality which he thus attributes to the intellect, speaking of it in a rhetorical manner rather than with the precision of philosophy. At any rate, as only asserting an immortality of such an abstract and undefined nature, he seems not unjustly to have been represented

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[1] *De Anim.* ii. 2, *και δια τουτο καλως ὑπολαμβανουσιν, οἳς δοκει μητε ανευ σωματος ειναι, μητε σωμα τι ψυχη· σωμα μεν γαρ ουκ εστι, σωματος δε τι, κ. τ. λ.* p. 633, Du Val. Εντελιχειαν appellat novo nomine, quasi quandam continuatam motionem et perennem. (Cicero, *Tusc. Qu.* i.)

[2] *De Anim.* ii. 1, *ει γαρ ην ὁ οφθαλμος ζωον, ψυχη αν αυτῳ ην ἡ οψις, κ. τ. λ.* p. 631.

[3] *Ibid.* ii. 3, *ὡ δ' αισθησις ὑπαρχει, τουτῳ ἡδονη τε και λυπη, κ. τ. λ.* p. 633. *De Animal. Motione*, c. 10, he compares the operation of the soul on the different parts of the body of animals, to a well-ordered state, in which the various offices are regularly administered, without requiring the presence of the monarch on each occasion. (P. 709, Du Val.)

[4] *De Anim.* ii. c. 7, *ἡ δε εντελιχεια του διαφανους φως εστι*, p. 639. *De Sensu et Sensil.* c. 2.

[5] *De Anim.* ii. c. 7.

[6] The eye, he says afterwards, sees only, *ῃ διαφανες*, so far forth as it is transparent, no otherwise than water or air. (*De Sens. et Sensil.* p. 664, Du Val.)

[7] *De Anim.* ii. c. 11, p. 644.

[8] He considers natural talent as connected with the delicacy of this sense. (*De Anim.* ii. c. 9, p. 642.)

[9] *Ibid.* iii. c. 3 and 4; *Metaph.* iv. c. 5. The term *imagination* must here be understood in the most general sense.

[10] *Ibid.* iii. c. 5, *επι μεν γαρ των ανευ ὑλης το αυτο εστι το νοουν και το νοουμενον*, p. 653.

[11] *Ibid. του δε μη αει νοειν το αιτιον επισκεπτεον*, p. 653.

[12] *Ibid.* iii. 6.

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as opposed to Plato on the doctrine of the immortality of the soul.[1]

As Aristotle included under Physics animate as well as inanimate nature, he has carried the historical part of his natural philosophy into both these departments. We have already mentioned his *History of Animals*, the precious relic of an extensive work, for which the materials were furnished to him by the conquests and the magnificence of Alexander. This fact alone excites an interest in favour of the work; and this interest is fully sustained by the variety of curious information contained in it respecting the structure and the habits of animals, indicating a power of the most minute observation.[2] He is said also to have written a work on Comparative Anatomy. There are extant among his works further illustrations of the animal economy, in treatises on the motion, the walking, the parts, and the generation of animals. In inanimate nature he has explored the causes of meteors, comets, earthquakes, of the rainbow, and other phenomena of the atmosphere, in a work on Meteorology. He has also separately discussed the nature of colours, and of the objects of hearing.

To this catalogue must be added two works which do not strictly fall under either department of nature, *The Problems*, containing queries chiefly on subjects belonging to Natural Philosophy, with brief answers,—a curious work, illustrative of his vast reach of observation, and his extraordinary sagacity in searching out the reasons of things; and a tract against the doctrines of Xenophanes, Zeno the Eleatic,[3] and Gorgias.[4]

In mathematics he has left very little comparatively. The only treatises under this head are, *The Mechanical Questions*, and a book *on Indivisible Lines;* both very inconsiderable works in themselves. But he had been trained in the school of Plato, whose threshold was not to be passed by the uninitiated in geometry; and had attained a perfect skill in the method of mathematical investigation then known. We do not want indeed more abundant proof of this, than is to be gathered from passages in his Physics, in which we find him often establishing conclusions by steps of mathematical demonstration.

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Dialectic.

Aristotle, we have remarked, was the first to separate the proper science of Dialectic from that confusion with Physics and Metaphysics in which it had been entangled and perverted. In doing this he laid the foundation of a sound and practical logic. There was a basis of truth, he saw, in the doctrine of Plato, which referred our knowledge of all sensible objects to certain abstract universal natures, the objects of pure intellect. But he saw also that Plato had entirely overthrown the right application of the doctrine, by imputing to these universals a real being; and, instead of treating them as the causes simply of our knowledge, identifying them with the actual elements or grounds of existing things. Having stated, therefore, the proper nature of these universals to be that of conceptions of the mind, by which it represents to itself things as they really are, and in this sense speculated on them abstractedly in the Metaphysics, he further considers them, in the treatises of the *Organon*, as they are employed dialectically, or are subservient to the communication of knowledge between man and man. There was indeed another view of the application of these universals, and prior to that of their employment in discourse, which remained to be considered. This was their use in enabling the mind to connect the phenomena of nature, or as they are *properly* the causes of our knowledge. But the state of philosophy in his time did not lead him to such an investigation. It was reserved for an age of more diffused civilization, and the adventurous genius of Bacon, to display the principles of that analysis by which the mind arrives at general principles, and obtains a real science of nature. The practice of colloquial discussion on questions of philosophy, recommended as it was by the instructiveness and interest of the conversations of Socrates, attracted the attention of the Greek philosophers to the mode of establishing conviction by deductions from admitted principles. Aristotle, accordingly, in elucidating the nature of universals as the causes of our knowledge, was naturally diverted from the higher path of investigation, to explore them as they acted through the medium of language. In pursuing this inquiry, he laid down the principles of a general science, applying to argumentation as such, to the inferences of the reasoner from probabilities, as well as to the most rigid demonstrations of the mathematician.[5]

Dialectic, in its widest sense, is the method of deducing the probabilities on either side of a question, so framed as to involve one of two contradictory propositions in the answer, according as the affirmative or negative of it is taken.[6] The discussions to which the term Dialectic refers being carried on by a series of questions and answers, the design of the art was, to furnish the means of sustaining these intellectual exercises, by supplying not only principles of correct reasoning, or rules of logic properly so called, but various modes of proof and helps to the invention of arguments.[7] To have a ready command of propositions on any given point, and of objections that might be brought against it, so as to be completely armed for debate, was the perfect accomplishment of the dialectician. This most obvious application of the science produced unfortunately, in the haste to supply arms for the disputant, instead of a philosophy of language, a misnamed science, conversant only about the intricacies of verbal quibbling. Zeno the Eleatic, Euclid of Megara, and Antisthenes, took the lead in framing systems according to this view of Dialectic. Nor do the dialogues of Plato, though rich in examples of reasoning, suggest any more just and exact method. Hence the logic which prevailed at the time of Aristotle, and which, from the long concealment of his writings, continued, even after his improvements in this branch of philosophy, to be the

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[1] Origen c. *Cels.* ii. p. 67, ed. Spenc.

[2] It was the authority followed by Pliny in his *Natural History*. Pliny, viii. 16, says in allusion to it, "vir quem in iis magna secuturum ex parte præfandum reor."

[3] So called in contradistinction to Zeno the Cittian, founder of the Stoics, from Velia in Italy, his birth-place.

[4] The treatise on plants edited with his works is acknowledged by critics not to be Aristotle's, but that of Theophrastus. The treatise *De Mundo* may also be regarded as now decidedly rejected from the number of his works, as also the *Collection of Wonderful Narrations*, and perhaps the *Fragment on the Winds;* the internal evidence of these tracts being against their imputed authorship. It is very probable that the works of Theophrastus were mixed with those of Aristotle, from the circumstances already mentioned respecting the transmission of the volumes of Aristotle.

[5] *Anal. Prior.* i. c. 1 and 30. *Anal. Post.* i. c. 11.

[6] *Top.* viii. cap. 2.

[7] *Top.* viii. cap. 5 and last chapter; Cicero *De Fin.* ii. cap. 6, and *Top. ad Treb.* cap. 2.

system of the Greek schools, was a mere collection of subtile points of argument, without any attempt to analyze the process itself of argument. His Dialectic is the reformation of that irregular and perplexed system. Whilst he adopts and explains the general notion of the science, as a method of defending or impugning an opinion, he takes a larger, more philosophical view of the subject; investigating the grounds, both in the nature of language and in the connections of thought, on which all arguments must rest. Hence his just boast, that, "with regard to the dialectic art, there was not something done and something remaining to be done,—there was absolutely nothing done; for those who professed the art of disputation resembled the rhetoricians of Gorgias's school. As these composed orations, so the other framed arguments which might suit, as they imagined, most occasions. These their scholars soon learned. But they were in this manner only furnished with the materials produced by the art,—the art itself they did not learn." He goes on in the same passage to observe, that "upon rhetoric much had been written; but on the art of reasoning, nothing. The whole of what he had composed on that subject was from himself;"—that he had "derived no benefit from former labours:" expressing his hope, accordingly, that what he had "left undone would be forgiven, and that what had been done would meet with a favourable acceptance."[1]

It is a singular fact in the history of science, that his labours in this arduous work should have suffered an unjust depreciation in modern times, by being estimated in contrast with the analysis of Bacon: whereas, according to his own challenge, and as the reason of the case suggests, they admit only of comparison with the efforts of his predecessors, and of the Stoics, who, though following him, wrought upon the ancient model of the science, and exhibited that in its utmost perfection. If we compare the method of Aristotle with what is known of the wrangling discipline of the Stoics, we shall then judge with more fairness of the philosophical character of his labours. His disciples were content to be ignorant of such dialectic as the Stoics taught,[2] though, from the untoward prevalence of that system down to the time at least of Cicero, it has probably been often confounded with that of Aristotle, and thus reflected its own disrepute on his more scientific system. With the method, however, of Bacon, the Dialectic of Aristotle has no natural rivalry. In the period of literature preceding the researches of Bacon, it happened that ingenious men, with a natural devotedness to the studies by which their minds had been moulded, sought to resolve the mysteries of science by a profound Aristotelian philosophy. Thus were principles of physics and metaphysics mixed up with the theory of language; as, on the other hand, principles belonging to the theory of language were previously applied to the analysis of nature. The writings of Aristotle were regarded as a kind of Scriptural philosophy, beyond which there was no appeal in controversies of science.[3] And when an authority of this kind is once established, it is easy to see that a philosophy of mere words will soon follow. Expounding and commenting on the text of the master supersedes the questioning of nature herself, just as a mere textual theology supersedes an enlarged study of the facts and scheme of Divine revelation. But this perversion is not to be regarded as the tendency of Aristotle's philosophy. Practically, indeed, he does not altogether keep clear of the seductions of realism; but in him it is only a *practical* infirmity. Theoretically, he was perfectly aware that "the subtilty of nature far exceeds the subtilty of human intellect;[4] and that, accordingly, to ascertain *what* things *are*, we must *know* them otherwise than according to dialectic. He would have dialectic employed for the purpose of stating and examining all the questions and difficulties belonging to any subject—not to supersede an acquaintance with phenomena.[5] He observes, that when, in inquiries concerning what a thing is, men are ignorant of the circumstances connected with it, they pronounce only dialectically and emptily;[6] thus pointing out the futility of applying an instrument of discussion to the business of philosophical investigation. So far, then, as dialectic, by sifting a question thoroughly, clearing up apparent inconsistencies, and pointing out where the truth lies, may be regarded as an organ of philosophy, so far Aristotle authorizes the inquirer to employ it. It may serve as the precursor and companion of investigation, but not as the substitute; and thus he describes it as a method of "trying," πειραστικη; whereas philosophy is a method of "knowledge," γνωριστικη.[7] It is quite opposite to his idea of dialectic to suppose it capable of furnishing principles. These, he expressly says, belong to the several sciences, by which they must be supplied to the dialectician according to the matter in hand.[8] To the philosophical *disputant* they are the *data* with which he sets out; or rather, so far as he is concerned with them, the hypotheses which he proceeds to discuss in their various points of view, tracing their connections with, or opposition to, other principles.[9] Aristotle, therefore, evidently did not intend that the philosopher, as such, should rest in the speculations of dialectic; and though he has not provided in his writings an instrument of investigation, giving only indirect hints of such a method, he supposes it actually resorted to in practice by the philosopher. His Dialectic, accordingly, instead of being put in contrast with the *Novum Organon*, is to be regarded as an auxiliary system, introductory to the latter, and enforcing its use.

The error of the scholastics in applying dialectical principles to the philosophy of nature, arose from their ignorance of the nature of philosophical truth. They do not seem to have been aware that philosophical principles are but expedients which the mind adopts for arranging the various objects of nature: otherwise, they would have seen that a science conversant wholly about the connections of our notions as expressed in language, could have no subserviency to the investigation, properly so called, of

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[1] *Soph. Elench.* ii. last chapter.

[2] Cicero introduces Cato in the character of a Stoic, speaking of the Peripatetics as deficient in acuteness, "on account of their ignorance of dialectic." (*De Fin.* iii. cap. 12.)

[3] Where a disputant quoted a passage from this philosopher, he who maintained the Thesis durst not say *Transeat*, but must either deny the passage, or explain it in his own way. (Bayle, *Dict.* art. *Aristot.* p. 469.) He refers, in evidence of this, to the *Courses of Philosophy*, printed in the 16th century.

[4] Bacon, *Nov. Org.* i. aph. 1.

[5] He sometimes expressly adverts to the difference between conclusions drawn εκ των φαινομενων and εκ των λογων, as *De Cœlo*, ii. cap. 13, p. 466; *De Gen. et Cor.* ii. cap. 10, p. 525; *Eudem.* i. cap. 6, p. 199, Du Val.

[6] *De Anim.* i. cap. 1, p. 617, Du Val.

[7] *Metaph.* iv. cap. 2, p. 871, Du Val.

[8] *Anal. Pr.* i. cap. 30; *Anal. Post.* i. cap. 1, 3, 9.

[9] Bacon rightly describes the "invention of dialectic," in saying, "Inventio enim dialecticæ non est principiorum et axiomatum præcipuorum, ex quibus artes constant, sed eorum tantum, quæ illis consentanea videntur." (*Nov. Org.* i. p. 82.)

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other sciences. When the facts of this science were reduced to certain fixed principles, the whole object of the science was accomplished—the result would be a philosophy of language; and to carry this philosophy into other matters, was an incongruity like that of uniting principles of mathematics and ethics.[1] There was at the same time a ground for their error, in the universality of language, as the medium by which the truths of every science are expressed; and its comprehensiveness, as it has the power of signifying by single terms an immense variety of objects. These imposing attributes of language gave at least the semblance of philosophizing to their *a priori* speculations. But had they studied more sincerely the writings of their master, they would have seen the real use to which the universality and comprehensiveness of language might be applied, without trespassing on the legitimate province of investigation.

A slight consideration of the nature of language may suffice to show the proper business of Dialectic. Language is the record of the observations of mankind on the course of nature. It is, as it were, a popular philosophy. Whatever may be its origin—whether words be merely conventional signs, as Aristotle teaches,[2] or have a foundation in the nature of the things denoted by them—still, their application to observed facts in the course of nature, is the result of the operation of the human mind; and words, in this use of them, are the creations of the intellect. The intellect takes up and applies the existing signs furnished by language, however derived, to mark and preserve for its future direction the dictates of its past experience. Thus, the application of the term "burning" to the observed effect of fire on a combustible body, is an act of the mind recording its experience of that effect. Having recorded its experience by this term, it thenceforth uses the term as a substitute for the actual experience. Proceeding on that fundamental law of human belief and action, that all things will continue in their observed course, it trusts to the word thus obtained as a guide to future conduct. It is sufficient to say that any thing "burns," to give us a representation of the effect of fire, and direct us in our actions with regard to that thing. Accordingly, by the use of terms, observations, in themselves individual facts, are generalized. The term, originally the record of a single experience, serving practically in the stead of a repeated experience, comes to stand for a number of individuals. From its practical application to a multitude of similar events, it obtains a speculative multiplication as the general expression of many particulars, or, in short, becomes a class-term.

It is thus that language may be regarded as a popular philosophy of nature. Each term denoting some observed event or object, is a general principle, connecting the several events or objects to which it admits of being equally applied. Whilst it practically enables us to decide and act in a number of individual cases, it also speculatively presents the means of anticipating a number of particulars, as notions implied in it; or, in other words, is a *theory* of the particulars which it denotes.

But when we have once obtained a variety of terms, thus representing in each of them a multitude of particulars, we can further generalize our observations by reflection on the notions themselves, and recording our observations on these, in like manner as on the real events and objects of nature. We then notice whether the notions implied by one term, are distinct from, or are included in, the notions implied by another; and, accordingly, we regard the terms respectively denoting them, as classes, either totally distinct, or as more or less comprehensive. We observe, for instance, whether the terms, "man," "animal," "vegetable,"—all being records of our observations on nature,—give us information of the same particulars, or of others entirely different: and we find that "man" and "animal" are but different views of the same individual, as for instance of Socrates; whilst the term "vegetable" is no expression of any observation whatever on the same individual. We find that "animal" represents to us more individual objects than "man;" so we regard it speculatively as a class including in it "man;" and both the terms "man" and "animal," as classes entirely distinct from the class "vegetable," because none of the observations referred to in either of the former are the same with those referred to in the latter.

These principles of language are the data on which the dialectical system of Aristotle is constructed. It is evident, from the mere statement of them, that there is such a thing as a scientific application of language to the purpose of instruction; for it is clearly seen to act as an instrument of knowledge by its very nature, independently of any art in the use of it. And it is for the philosopher, therefore, to inquire how it acts in producing this effect.

Now, in order to a science of Dialectic, the first step appears to be, to reduce those various observations on existing things, so far as these observations are characterized by language, into some definite classes: for we thus bring them out of that perplexing infinity which defies all grasp of the intellect, and obtain a few comprehensive theories, under which the whole intellectual world may be surveyed. These classes will represent to us all the different forms or modifications of being, so far as it is capable of being denoted by language. The next step is to examine the principle of classification in itself, and notice the varieties of form which it takes; as the observations that are made on any individual give us more or less comprehensive, more or less invariable and scientific, views of the individual. The first step leads us to the Predicaments or Categories, general designations under which all the various abstractions of the mind are conveniently arranged for the purpose of the dialectician. These constitute, as it were, the fixed land-marks by which he may know the limits of each notion with which he has to do in any discussion. They are the great sections in the geography of the intellectual world which it is his office to explore and describe. The next step leads us to the Predicables, or various modes of classing the same object. Here we enter on that part of the science which is purely dialectical. In the arrangements of the Categories, the inquiry is partly metaphysical, partly logical. We are there philosophizing on the notions of the mind in connection with language; but here, we examine the principle of classification evidenced in language, *in itself*, and endeavour to obtain comprehensive views of all the varieties of form under which it appears.

Thus far the science of Dialectic was sketched out before the time of Aristotle. The Pythagorean philosopher, Archytas of Tarentum, has the merit of having instituted

[1] Aristippus complained of mathematical science, that it gave no account of good and evil. (*Metaph.* iii. c. 2.) As unreasonable is the complaint of the barrenness of invention of the Aristotelian logic. Aristotle, however, asserts that mathematics do give information about το καλον (*Metaph.* xi. c. 3), evidently misled by an abstract term, equivocal in its wide extent of application. His reason for the assertion will appear the better by observing that he included astronomy, among other branches of natural philosophy, under mathematics.

[2] *De Interpret.*

those arrangements of the objects of the intellect, which Aristotle adopted and explained under the title of *the Categories*. The objects of the mind are evidently referable to two ultimate classes. We either contemplate objects as they exist *simply*, or we abstract some particular attribute of them, and invest it with a being of our own creation. But as these attributes are various in kind, we require some more distinct classification of them; and this is furnished in the ten Categories. 1. Being; 2. Quantity; 3. Quality; 4. Relation; 5. Place; 6. Time; 7. Situation; 8. Habit; 9. Action; 10. Passion;—Being denoting, primarily, objects as they are conceived actually to exist in nature; secondarily, the notions of them as so existing; and the remaining Categories denoting the mere abstractions of the human mind. These several terms are admirably explained by Aristotle in his treatise on the Categories; and thus he commences his dialectic with a broad and deep foundation of metaphysical truth for the structure which is to follow. This treatise being further introductory to a method, not simply of reasoning, but of producing conviction on any subject, he includes in his survey the principles denoted by the terms, "opposite," "contrary," "prior," "co-existent," "motion," "having," —terms of frequent recurrence in the ancient philosophy, and therefore demanding notice in a work on Dialectic.

Aristotle has no distinct treatise on the several heads of classification, or classes of Predicables as they are technically termed; but has interwoven some account of them in the Metaphysics and Topics[1]—evidently regarding this department of his subject as already known to his hearers. He states them as four—property, definition, genus, accident. They are deducible from the consideration of the several points of view under which the same object may be contemplated. We may view it, either as it falls under some general observation, and is accordingly denoted in language by some class, the "genus,"—or in some circumstance belonging to it;—and this circumstance may be either peculiar to it, in which case it is a property, —or occasional, in which case it is an accident. Further, as the property of a thing may include all the peculiarities belonging to it, or only some one or more of these peculiarities; if it includes all, it becomes the definition of the thing,—in the latter case it is simply a property: so that there result the four classes already mentioned. In logical treatises we commonly find another class subjoined—the differentia or characteristic; and Aristotle himself refers to it, though he does not consider it necessary to regard it as a head of classification distinct from genus. It differs indeed from genus, only inasmuch as, so far as any class is called a differentia, it is so relatively to some other genus in which it is included as subordinate. How it is that the properties and accidents of an individual are considered as classes, will be evident from the generalizing power of language already noticed.

In the Categories, then, we have the Metaphysical Being of things, so far as it is denoted by language, drawn out into its various modes, and distinctly characterized in each. In the classes of Predicables, we have the Dialectical or Logical Being, or the various modes of existence created by language, through its power of comprizing multitudes under single terms. If, for example, we say "Socrates is wise," the metaphysical being here asserted is an abstraction of the mind, coming under the category of Quality: we are speaking of Socrates, not as he is individually, but as the *quality* of wisdom exists in him. But in the same expression the dialectical or logical being asserted is, the existence of Socrates as an individual in the class to which the term "wise" belongs.

It is highly important to observe this distinction between metaphysical and dialectical being; as the right understanding of the whole doctrine of propositions and syllogisms is dependent on it. Every proposition then, viewed dialectically, is the reference of one class of objects to some other class, in the case of an affirmative,—the exclusion of one class from another, in the case of a negative. The "being," or the "not being," is the being implied or not implied in a certain term. The schoolmen, unfortunately, neglecting the distinction here adverted to, and thus reverting to that confusion of logical and metaphysical science which Aristotle's whole philosophy had laboured to remove, included both kinds of being under the common term "universals." Evidently, however, it cannot properly be said of being, as it is apprehended by the mind, that it is an universal. A notion of the mind is in itself an individual; and its extension to more objects than one is simply an effect of the mental power of generalization. But the logical being is by its very nature an universal; since a term, so far as it is a class, comprizes in its meaning every individual that admits of being referred to it as a class.

Accordingly, to examine propositions dialectically, we have only to inquire into the relative comprehensiveness, or relative exclusion, of the terms conjoined in it. In this point of view, all propositions, on any subject whatever, are reduced to four kinds;—universal affirmative, in which one class is affirmed of the whole of another; universal negative, in which two classes are mutually excluded; particular affirmative, in which one class is affirmed of some of the particulars included in the other; particular negative, in which one class partly excludes another. These are the only varieties of form under which any two classes of objects can be combined in affirmations or negations. Every proposition, accordingly, in order to be brought under the survey of Dialectic, must be referred to one or other of these forms, as the case may be. Hence we may proceed to examine these ultimate forms to which propositions are reducible, independently of the things themselves about which the propositions are, and draw from them logical principles applicable to every particular case. Thus, the form of an universal affirmative, "every A is B," in which the letters A and B are put as the representatives of any objects whatsoever, is the proper dialectical datum, from which the whole logical nature of any universal affirmative proposition may be explored. So also with regard to the remaining abstract forms.

Aristotle, accordingly, in his treatise on *Interpretation*, and in the commencement of his *Prior Analytics*, has thus examined the nature of propositions, and deduced practical rules by which their force as principles employed in reasoning may be readily ascertained. It has been objected to him, that he resorted to these abstract symbols rather than to more familiar means of illustration, in order that he might leave the truths of the science partially veiled at least in obscurity. There may be some truth in the assertion generally, that he did not intend that his written works should be accessible to the public without the accompaniment of oral exposition.[2] But it does not apply here. The observation already made on the nature of dialectical being, may be sufficient to clear up any misconstruction of the philosopher on this point. The simple principle of classification, which is all that Dialectic is concerned with, could not so strictly be ex-

[1] *Topic.* i. c. 4.

[2] Plutarch speaks of the metaphysics as useless for general instruction, and rather as a suggestive treatise to those who had been originally disciplined: ὑποδειγμα τοις πεπαιδευμενοις απ' αρχης. (*Life of Alex.*)

amined, in any other way but that which expresses the principle itself nakedly. Every thing else is irrelevant to the matter in hand. So far as any thing else is attended to in a proposition, so far the mind is diverted from the logical point of view. His use of symbols, therefore, is only an illustration of his accurate and perfect method of developing the science.[1]

In his *Prior Analytics* he passes on to the consideration of syllogisms, or arguments logically viewed. Here it is that the dialectical theory is properly unfolded. Syllogisms are the perfect developments of the theory of language, as language is expressive of being,—manifestations of the general fact, that every term denoting being is the representative of a class of observations more or less comprehensive on some object.[2] This theory is first intimated in the ordinary use of single terms. It is next more disclosed in the connections of terms, *i. e.* in propositions affirming or denying one term of another. It is lastly laid open in the syllogism, in which the principle of classification is exemplified as the tie of connection between two terms affirmed or denied of each other.

Since, then, the evidence of the connection subsisting between the terms brought together in any affirmation or negation is *the point* in every argument; it is evident that the reasoning on any subject whatever may be exhibited abstractedly from the particular subject about which it is. Terms can only be connected as they are classes more or less comprehensive of each other; and this relative comprehensiveness is evidenced at once, as before shown, by the abstract forms of the propositions in which they are connected. Three abstract propositions, accordingly, in which the terms whose connection is explored, are, first (*i. e.* in the premises), separately stated in their relation to some intermediate class or middle term,—and then in their relation to each other (*i. e.* in the conclusion), as it is the result of their premised relations to the intermediate class,—will enable us, without reference to any other consideration, to judge of the conclusiveness of the argument. The syllogism is nothing more than this abstract statement of an argument.

Aristotle examines all the varieties of form which arguments thus abstractedly stated, or syllogisms, admit; whether from the position of the middle term in the premises, or from the different combinations of the four great classes of propositions; pointing out, under what arrangement of the middle term, what particular modes of argument alone are valid. From his whole examination, the conclusion results, that, under whatever form an argument may be expressed, the principle of the reasoning is the same in every case; each instance developing the theoretic power of language, according to which every term, so far as it denotes being, is a class, more or less comprehensive, of observations on the thing whose being it denotes.

This ultimate principle of all reasoning is commonly stated in the form of a theorem, enunciating, that "whatever is predicated (affirmed or denied) universally, of any class of things, may be predicated in like manner of any thing comprehended in that class." This is that form of it known by the scholastic designation of the "*Dictum de Omni et Nullo.*" From the mode in which this principle has been introduced in systems of logic founded on the method of the school-authors, a prejudice has been excited against Aristotle, as if he had employed the principle in establishing the conclusiveness of arguments already granted to be conclusive. Aristotle, however, does not introduce the principle in any formal manner, as a dogma or *a priori* ground of logical truth. On the contrary, it pervades the whole of his system, as resulting from every part of his inquiry. He is only concerned to show that every argument, however varied in its mode of expression, is redueible to a form by which the truth of his theory shall be evidenced in it. Syllogisms are not proved by the principle, but the principle itself is proved by the nature of the syllogism, as any other philosophical truth is deduced from varied observations and experiments. In short, by his reference to the principle, he does not *prove* the conclusiveness of a given argument, but *accounts* for it.

It is necessary to observe that most of the technical phraseology of modern treatises of logic is derived, not from Aristotle immediately, but second-hand, from the scholastic expositors of his doctrines. These ingenious professors of science, in carrying the notions of his physics and metaphysics into the science of logic, obscured, by the barbarian dialect in which the truths of the science were thus delivered, its proper nature as an art of language. Thus, according to them, we hear of the "substance," and "matter," and "form," both of propositions and of syllogisms, and other such irrelevant designations. On the contrary, the technical expressions of Aristotle himself are extremely few, and those strictly appropriate to the subject, elucidating the characteristic nature of the science as conversant about words. The scholastic method, however, from its long usurpation, has so engrafted itself on our modes of writing and speaking, that some acquaintance with its detail is in fact become necessary to us at this day; and may so far, therefore, be regarded as constituting a legitimate part of modern Dialectic. But when the cumbrous technicalities of this system are made a ground of objection to the Aristotelian logic, it may be explicitly answered, that these are not parts of Aristotle's system, as it is found in the *Organon*, but are the refinements of his commentators.

Having pointed out the several classes of syllogisms, into some one or more of which every valid argument must fall, Aristotle, in pursuit of the adaptation of his works to the business of disputation, proceeds to show the various expedients in argument resulting from the consideration of these abstract forms. This part of his subject is prosecuted through the remainder of the first book of his *Prior Analytics* and the second of the same treatise.

The examination of syllogisms is followed up in the *Posterior Analytics* by an inquiry into demonstration; and in the *Topics*, into arguments founded on probable premises. The full discussion of the syllogism was premised by Aristotle, inasmuch as the syllogistic process is common both to demonstration and to probable conclusions; and accordingly, as the more general subject of investigation, claimed the first notice in a scientific treatise of Dialectic. Properly, indeed, being the only part of the science which is really universal,—belonging to argumentation *as such*, under whatever form, whether by induction, example, or enthymeme (all of which are only different modes of expression of the syllogism), and whether the premises assumed be necessary or probable,—it is the only province to which the science of reasoning legitimately extends. In examining distinctly the nature of demonstration and of probability, we depart from the rigorous limits of the science of reasoning, and approach those of rhetoric. But it is useful, at the same time, to examine these subjects as detached from rhetoric, and in their connection with logic; so far as we then confine our attention to the mere force of different kinds of argument on the *understand-*

[1] The use of unmeaning symbols in logic rests on the same footing as their use in geometry and algebra.

[2] A *proposition* that is false is truly a proposition, whereas what is called an *invalid* argument is strictly no argument at all, because it does not exemplify the classification implied in the right use of terms.

ing; whereas rhetoric combines also the view of them in their effect on the will. We then consider them as they are capable of producing either knowledge or opinion; whereas, in the latter case, we look at them in that complex result which is implied in persuasion. It was for the former purpose that they were required for the dialectical disputant: and thus it is that the consideration of them forms an important part of the *Organon.* For the same reason the treatise on *Sophisms,* which forms the conclusion of the *Organon,* is directed not only to the solution of fallacies which may exist in the syllogistic process, or in the reasoning strictly viewed as reasoning, but to such also as may be traced in arguments where the process itself, the mere logic of the case, is perfectly correct.

The discussion of demonstration is an exposition of the nature of science, επιστημη, as it was understood by the ancient philosophers. They restricted the application of the term to the knowledge of necessary truths; such truths as, when ascertained, were known at the same time to be incapable of being otherwise. Aristotle, then, is employed, in the *Posterior Analytics,* in discussing the nature of the principles on which science, as it was then understood, must be built. Here he had to encounter perplexities and misconceptions introduced into the subject by the Platonic philosophy. In Plato's system knowledge was mere reminiscence. It was a penetration of the mind through the veil of the sensible universe interposed between itself and the realities of the intellectual world —its return to those purer perceptions which it had enjoyed before its union with a body. This doctrine was altogether founded on a fallacious view of the nature of demonstration. Because in demonstration the conclusion is necessarily implied in the premises, it was conceived that a science or proper knowledge of any particular was in all cases founded on a knowledge of the general principle in which it was implied. But this was an inversion of the order of knowledge, which commences with the particular, and ends in the general principle. In mathematical and metaphysical science the two things coincide; the notions of our mind being, on the one hand, in themselves particular facts, from which we may argue, to general principles; and, on the other hand, in their application to the business of philosophy, being the general principles of our knowledge. But Plato argued from this coincidence in these sciences to the sciences in general, and therefore confused demonstration with the scientific arrangement of facts. Aristotle, we find, was not free from the same fault in his Physics; but in his theory of Demonstration he has strictly provided against it. He has here pointed out the difference between the proof of matter of fact and of matter of abstract speculation. Instead of inculcating the necessity of establishing every conclusion in science by syllogism or a demonstrative process, he shows that all demonstration proceeds on assumed principles; which principles, accordingly, must be obtained from observations generalized, and not from reasoning.[1]

There is one part of the work which deserves a more particular notice, as throwing light on his whole method of philosophizing, while it shows how far he approximated to the induction of modern philosophy. To obtain an accurate notion of the being of any thing, we require a definition of it. A definition of the thing corresponds, in dialectic, with the essential notion of it in metaphysics. This abstract notion, then, according to Aristotle, constituting the true scientific view of a thing,—and all the real knowledge consequently of the properties of the thing depending on the right limitation of this notion,—some exact method of arriving at definitions which should express these limitations, and serve as the principles of sciences, became indispensable in such a system of philosophy. But in order to attain such definitions, a process of induction was required—not merely an induction of that kind, which is only a peculiar form of syllogism, enumerating all the individuals implied in a class instead of the whole class collectively—but an induction of a philosophical character, and only differing from the induction of modern philosophy so far as it is employed about language. We shall endeavour to show this more fully.

There are, then, two kinds of induction treated of by Aristotle. The first, that of simple enumeration. Its use is, where we have not beforehand ascertained a class to which we may refer the subject of our conclusion, and the search is in fact for a middle term. In this case, then, a collection of all the individuals which are supposed to make up the class, serves instead of a middle term. Assuming, accordingly, that these individuals are equivalent to the class, we draw the conclusion, that what has been affirmed or denied of these collected individuals may be affirmed or denied of the class. This, then, is nothing more than a syllogism. There is no process of investigation involved, but it is assumed, that we have found the assertion made, true in all the individual instances; and the induction itself is simply the process of bringing them under a principle of classification.

But there is also a higher kind of induction employed by Aristotle, and pointed out by him expressly in its subserviency to the exact notions of things, by its leading to the right definitions of them in words. As it appears that words, in a dialectical point of view, are classes more or less comprehensive of observations on things, it is evident that we must gradually approximate towards a definition of any individual notion, by assigning class within class, until we have narrowed the extent of the expression as far as language will admit.[2] The first definitions of any object are vague, founded on some obvious resemblance which it exhibits compared with other objects. This point of resemblance we abstract in thought, and it becomes, when expressed in language, a genus or class, under which we regard the object as included. A more attentive examination suggests to us less obvious points of resemblance between this object and some of those with which we had classed it before. Thus carrying on the analysis,—and by the power of abstraction giving an independent existence to those successive points of resemblance,—we obtain subaltern genera or species, or subordinate classes included in that original class with which the process of abstraction commenced. As these several classifications are relative to each other, and dependent on the class with which we first commenced, the definition of any notion requires a successive enumeration of the several classes in the line of abstraction; and hence is said technically to consist of genus and differentia; the genus being the first abstraction, or class to which the object is first referred, and the differentia being the subordinate classes in the same line of abstraction.

Now the process by which we discover these successive genera is strictly one of philosophical induction. As in the philosophy of nature in general, we take certain facts as the basis of inquiry, and proceed by rejection and exclusion of principles involved in the inquiry, until at last,—there appearing no ground for further rejection,—we con-

[1] *Analyt. Post.* ii. c. ult. 7, 4, i. 13.

[2] *Ibid.* ii. c. 13, Ζητειν δε δει επιβλεποντα επι τα ομοια και αδιαφορα, πρωτον τι απαντα ταυτον εχουσιν, κ. τ. λ. p. 175, Du Val.

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clude that we are in possession of the true principle of the object examined; so in the philosophy of language, we must proceed by a like rejection and exclusion of notions implied in the general term with which we set out, until we reach the very confines of that notion of it with which our inquiry is concerned. This exclusion is effected in language, by annexing to the general term denoting the class to which the object is primarily referred, other terms not including under them those other objects or notions to which the general term applies. For thus, whilst each successive term in the definition, in itself, extends to more than the object so defined,—yet all viewed together do not; and this their relative bearing on the one point constitutes the being of the thing.[1] This is thus illustrated by Aristotle: "If we are inquiring," he says, "what magnanimity is, we must consider the instances of certain magnanimous persons whom we know, what one thing they all have so far forth as they are such; as,—if Alcibiades was magnanimous, or Achilles, or Ajax,—what one thing they all have; say 'impatience under insult;' for one made war, another raged, the other slew himself: again, in the instances of others, as of Lysander or Socrates,—if here it is, 'to be unaltered by prosperity or adversity;'—taking these two cases, I consider, what this 'apathy in regard to events,' and 'impatience under insult,' have the same in them. If now they have nothing the same, there must be two species of magnanimity."[2] So, again, he suggests a similar process in order to ascertain the nature of any thing. He directs that the investigation should commence from the genus: since, having discovered the properties or sequences of the genus, we have also the sequences to the next class in the series,—and so on from that class to the next in order,—until by this continued process we reach the individual object examined. In the course of investigation, also, he observes that we should attend to whatever is common, and examine to what class of objects that belongs, and what classes fall under it;[3] and for the same reason select analogies; since in both these instances we obtain genera, under which the object investigated may be arranged. The process is virtually the same, as if we should investigate a law of nature. But the induction of Aristotle, having for its object to determine accurately in words the notion of the being of things, proceeds, according to the nature of language, from the general, and ends in the particular; whereas the investigation of a law of nature proceeds from the particular and ends in the general. Dialectical induction is synthetical, whilst philosophical induction is analytical, in the result. The former labours to particularize as much as possible, counteracting the uncertainty occasioned by the generalizations of language; whilst the latter is engaged in penetrating the confused masses in which objects first present themselves to the mind, and exploring their most general and characteristic form. Thus, the induction of Aristotle was strictly επαγωγη, or the bringing term on term, each successively limiting the application of the preceding one in regular series, so that at length a distinct notion may be presented of the object defined.[4] The notion thus obtained in words is the *logos* or expressed reason of the being of the thing; and hence perhaps the prevalence of the name logic[5] as appropriate to this branch of science, instead of the more general and ancient designation of dialectic, which expresses rather the application of the science to practice than its philosophical nature.

It would appear, then, that Bacon has not done justice to Aristotle in the contemptuous manner in which he has spoken of the induction taught by Aristotle. It is certainly limited in its design, as having for its object the correct statements of the particular notions on which an inquiry turns, rather than the discovery of new truth; and it is not set forth with that fulness of method which Bacon developed in the *Novum Organum*. But it is sound and valid so far as it reaches, and proves that Aristotle was not intent on corrupting philosophy with dialectic, but rather on applying dialectic to that very purpose which Bacon himself so much insists on—the bringing the intellect even and unprejudiced to the business of science. Of the application of induction in its full philosophical extent, Aristotle presents abundant specimens, and particularly in his treatises on Ethics and Rhetoric. His discussion of the passions in the latter treatise is a masterpiece in that way. He sets out, indeed, abstractedly with definitions of the several passions, but these are the results at which he has arrived by induction, being obtained, as his subsequent observations show, by a close interrogation of nature, by examining accurately, what belongs, or does not belong, to each particular passion, and thus adducing its exclusive character or proper form.

Rhetoric.

As the speculative sciences had been confounded under a vague notion of dialectic, so had rhetoric, in the ostentatious study of it prevalent before the time of Aristotle, drawn into its system the practical sciences of Politics and Ethics. Observations had been accumulated on the mere accessories of the art; but the proper business of the rhetorician, the inquiry into the argument itself of which a composition must consist, had been overlooked. Aristotle had therefore to dig a foundation for the fabric of a real science of rhetoric. He had to clear away misconceptions; to show the data on which rhetorical science must proceed, and the relative importance of its several parts.

He commences, accordingly, with pointing out the nature of its connection both with dialectic and with moral science. It is first and most directly connected with rhetoric, inasmuch as it is a general method of providing arguments on any subject whatever. As dialectic examines and discusses the principles of various sciences, considering them in their relations as principles in the abstract, and not as the principles of this or that science, and is so far equally conversant about all subjects; so rhetoric inquires generally into the nature of principles of persuasion, and therefore is also of equal application to the various subjects of human thought. In the discussion of these abstract principles under the head of dialectic, it was found that they were referable to two general classes —that they were either probabilities or necessary truths. And Aristotle, accordingly, after having explained the nature of syllogism, or the more general connection of

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[1] *Analyt. Post.* ii. c. 13, ὧν ἑκαστον μεν επι πλεον ὑπαρξει, ὡπαντα δε μη επι πλεον· ταυτην γαρ αναγκη ουσιαν ειναι του πραγματος, p. 173, Du Val.

[2] *Anal. Post.* ii. c. 13, p. 175, Du Val.

[3] *Anal. Post.* ii. c. 14.

[4] See also *Anal. Prior.* ii. c. 23, p. 125, Du Val. The use of επαγωγος (Thucyd. *passim*), as applied to arguments of inducement, may illustrate the sense of επαγωγη. A person is brought over to some persuasion by consideration urged on consideration, so as at length to bring him to the point required. We are brought, in like manner, to the knowledge of the nature of a thing by term brought on term in a definition, the force of each of which singly is vague and weak, but of all *collectively* strong and direct to the point. The απαγωγη, abduction, spoken of by Aristotle (*Anal. Prior.* ii. c. 25), is just the reverse, a leading away, by the terms successively brought, from the more accurate notion conveyed by a former one.

[5] Aristotle uses the adverb λογικως, as in *Metaph.* vii. c. 4, but not the noun λογικη to denote the science.

principles, which is independent of their peculiar nature, proceeded to investigate the nature of deductions as drawn from necessary principles or from probabilities. The consideration of this distinction anticipates in some measure the province of rhetoric, touching on the point, as we have already observed, in which rhetoric differs from logic strictly so called. As the science of eloquence, its office is to speculate on the effect of different principles in producing conviction, and not simply on their abstract relations, and therefore it must examine the relative force of arguments as they are probable or necessary. Principles, in short, as they are grounds of credibility, and not as they are the basis of a reasoning *process*, constitute its proper subject; and in this respect it coincided with a part of the ancient dialectic. But it differs again from dialectic, inasmuch as it is connected also with moral science. In dialectic the force of man's moral nature on his opinions is not considered. Will such or such an opinion result from such or such arguments, according to the procedure of the human intellect in forming its judgments,—is the whole inquiry of dialectic. But rhetoric further considers, what is the practical force of such and such arguments; what effect are they found to have in actual experience; not according to their mere speculative force, but as acting on the complex nature of man; through which it happens that questions are not examined on their positive merit as simple questions of truth, but with feelings and sentiments thwarting or biassing the discernments of the judgment. Here, then, is opened a wide field for a philosophical inquiry of a peculiar character, distinct from dialectic, and yet strictly founded on it and implying it throughout, as well as of the highest importance in order to the success of truth in the world. This inquiry is what Aristotle institutes under the head of rhetoric.

He has shown the most perfect comprehension of the nature of the science which he had undertaken to develope in this view of it, by holding it in exact balance between the two sciences of dialectic and morals with which it is associated. There is much of logical matter in the course of his inquiry, and still more of ethical; but he never suffers us to forget that we are not examining those sciences *in themselves* now, but in their relations to one compounded of both. He would have the rhetorician versed in dialectic, and deeply acquainted with human nature; but he is intent on showing him how he is to apply his knowledge of both these sciences to the proper business of rhetoric—the influence on the mind of the hearer or persons addressed. It is not a vague and popular knowledge of those sciences which he is inculcating throughout, but a popular application of authentic principles drawn from them both, and a popular application founded on a deep philosophy of human nature.

This philosophy consists in an investigation of the kinds of evidence by which the minds of men are commonly swayed in accepting any conclusion proposed to them, and of those principles of their moral nature by which their judgment is commonly influenced. The whole, accordingly, is an inquiry into what is probable or persuasive to a being so constituted as man.

Rhetoric, then, considers arguments not as they are abstractedly necessary or probable. This is a question relative to opinion alone; and the result from arguments under this point of view is, either a full conviction, or a presumption of some point in question. Rhetoric, on the other hand, looks simply to probability in the *result*. Whether an argument be necessary or probable in *principle*, is of no consequence to the rhetorician, provided it be persuasive in its *effect*. He has to consider, therefore, only a probability of this kind—on what grounds men commonly believe an argument to be just.[1] Now men are found to receive arguments as conclusive on two different grounds—either as considering them logically sound, deducible from admitted principles, or as coincident with their own previous observations. Hence the distinction between probability and likelihood; probability denoting conclusions which appear to have been proved by some reason alleged—likelihood denoting conclusions grounded on matter of fact, the conclusion being something like what has been experienced. Aristotle distinguishes these two kinds of rhetorical arguments as probabilities, εικοτα, and signs, σημεια. The precise nature of the distinction he explains more fully in his Analytics.[2] In his Rhetoric he directs our attention rather to those practical forms which the two classes assume in enthymemes and examples; enthymemes being such arguments as state a conclusion with the reason of it—examples, arguments in which a conclusion is drawn from particular facts, or observations.

He points out, accordingly, the force and propriety of enthymemes and examples, as modes of producing conviction in themselves, and relatively to each other, according to the subjects in which they may be employed. And as enthymemes are the more comprehensive head—for, in fact, every argument from example is in principle an enthymeme, the example cited being in this case the reason of the conclusion—he dwells more explicitly on the nature of enthymemes. These he distinguishes, as they are entirely abstract arguments, unconnected with any particular subject, and equally common to all subjects; or as they are drawn from particular subjects, and belong to particular sciences. Instances of the former class (τοποι, the *loci* of Cicero) are conclusions of the possibility of any thing from abstract considerations of possibility,—of the existence of any thing from the existence of that which implies it more or less. Instances of the latter (the ειδη of his system) are conclusions drawn from some observation of the nature of human actions, or from some principle of government or commerce, &c.; to which the rhetorician has occasion to appeal, so far as some particular subject is considered in the arguments of every speech.

The matter of proof, or the grounds of credibility in themselves, being obtained, it comes in the next place to be considered how this proof is acted on and modified in the result by the complex nature of man, on whom the result is to be produced. The subjects to which rhetoric properly applies are those in which there is some opening for the action of the moral feelings. In questions of pure science the intellectual powers alone are concerned. There is no personal application to the individual; no reference to his own experience for the proof of the principles, as is the case with all inquiries involving human conduct; where a fairness of judgment is as much

[1] We must be careful, therefore, how we understand the assertion, that dialectic is concerned about truth, and rhetoric about opinion. It is to be understood simply that rhetoric has not for its object to discover what any particular thing *is*, but to discover what will give a *persuasion* or *belief* that it is. At the same time, those principles on which such a persuasion depends, are real truths about which the science is conversant; whence it is called by Aristotle the philosophy of discourse, ἡ των λογων φιλοσοφια, *Rhet. ad Alex.* cap. 1.

[2] *Anal. Prior.* ii. cap. ult.; *Rhet. ad Alex.* cap. 9, 13, 15.

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required in order to an acknowledgment of the principles, as a clearness of intellect. Whatever may be the nature of a mathematical enunciation or a fact in chemistry, when it is once stated and proved, there is no question whether we approve or disapprove it. Its truth is suffered to rest on its proper footing. But a conclusion respecting our own nature, or involving our own conduct, immediately calls all our moral principles to the survey of it. Our hopes, and fears, and wishes, are heard pleading for or against it. And here, then, is the proper province of the rhetorician. He is the advocate by whom the case is to be laid before these internal judges: he is to prepare the evidence for their reception; and by his knowledge of their former judgments, to present the truth before them in such form, that it may obtain a fair hearing, and be affirmed in their decisions.

For the convenient arrangement of rhetorical arguments, Aristotle divides rhetoric into three different kinds, according to the different occasions on which it was employed among the Greeks:—1. The deliberative, or its use in political debates; 2. the judicial, or its use in popular assemblies, as those of Athens, in which the people collectively exercised the judicial functions; 3. the demonstrative, or its use in panegyric and invective, when the orator had only to gratify his hearers by the display of eloquence.[1] In these several heads of inquiry he has given an admirable philosophy of the motives by which mankind at large are commonly actuated in their conduct and opinions. And here we should notice the peculiar complexion which the happiness and the virtue, described in this part of his philosophy, assume. He is led to speak of happiness[2] as the great object of human desires—the point from which all views of expediency obtain their colouring. But here he is not concerned to illustrate that happiness to which the aim of mankind *should be* directed, but that which is *in fact* sought in the world as it is. He therefore portrays those various distinct forms with which self-love invests the idea of happiness; it being evidently more to the purpose of the orator, to conform his arguments to the views entertained by his hearers, however theoretically false, than to a more just theory, of which they have no conception. Virtue, again, is here a law of honour.[3] It is an appeal to those right feelings which exist in the nature of man, by which virtue is approved and vice disapproved. Independently, however, of discipline and mature reflection, these feelings are not found in fact always duly exerted: and there is ground, therefore, for a popular kind of virtue, in a philosophical survey of those principles by which the human heart is *commonly* swayed in its decisions of right and wrong. This law of right is at least an approximation to perfect virtue. It is an irregular and uncertain application of the criterion of praise, which belongs to virtue, leading to the preference of the more ostentatious virtues to the less obviously praiseworthy; and to the exaltation of some qualities to the rank of virtues, through the want of discrimination in the popular estimate. Thus virtue becomes, in the popular view, a power of doing good,[4] rather than an internal habit of self-moderation. Men acquiesce in that general notion of it, under which it most strikes their attention and calls forth their admiration. But this is evidently the virtue to which the orator must make his appeal. He cannot calculate on finding his hearers moral philosophers, or persons whose sentiments have been highly cultivated. He must therefore proceed on those broad principles which may be presumed to exist in the heart of every man; and to these he must conform his arguments in order to produce a moral impression.

Further, as the habits of thinking and feeling among men are found to be affected by peculiarities of circumstances, it is necessary for the orator to have studied also the varieties of human character, and to have reduced these to general principles for his practical direction. Aristotle, accordingly, has not lost sight of this point in his Rhetoric, but has shown a keen discrimination in the outlines which he has given of the effects of different governments, different periods of life, different worldly fortunes, in modifying the human character.

He had strongly condemned former rhetoricians for making the whole art consist of an appeal to the passions; but at the same time he was aware that such an appeal was a necessary part of the orator's address, and that no arguments, no merely intellectual proofs, could avail, independently of this. To neglect, indeed, the affections in arguments concerning human conduct, is to neglect the proper authorities to which the whole process of proof is ultimately addressed. Wherever evidence is not absolutely irresistible, and there is room for doubt,—though there be no further object than simply to produce belief,—the hearer naturally proceeds in his analysis of the evidence, until he brings it home to himself, and finds that it terminates in some principle of his own nature. This it is that at last determines the wavering balance. The philosophy of rhetoric, therefore, required of Aristotle to give outlines of these ultimate arbiters of all rhetorical questions. And we are indebted accordingly to his masterly view of the subject, for an accurate and beautiful delineation, in the course of his principal treatise of rhetoric, of the leading passions of human nature. Of its excellence as a specimen of the inductive method of philosophizing we have already spoken.

In treating both of the virtues and of the passions, Aristotle's view was to enable the orator not only to recommend his arguments to the moral sentiments and feelings of an auditory, but to bring also to their support the natural prejudice from authority. We involuntarily ascribe, to one who appears in the character of an instructor, the advantages of superior knowledge and kind intentions; and the prejudice in favour of authority is thus reasonably founded on a respect for wisdom and virtue. It is important, then, to the orator to avail himself of this prejudice. There must be nothing in a speech that may counteract the natural tendency to believe in the speaker. On the contrary, his whole argument must conspire with it. It must give the impression that he is a man of intellectual ability, as well as of right sentiments and feelings. Hence Aristotle deduced a third class of rhetorical proofs under the head of ethos or character; the pathos or appeal to the passions, and the argumentative proof as such, constituting the two other heads of classification. He thus shows how a speech may at once carry conviction, interest the feelings of the hearer, and give the weight of personal authority to the speaker.

In the popular views of rhetorical science, the subjects of style and method engross an undue importance. We are thus led to think that eloquence consists in the skilful use of the ornaments of style, in the flow of periods, and the structure of the composition, advantageously distributing its lights and shades. The attention is diverted

[1] *Rhet.* i. cap. 3, &c.; *Rhet. ad Alex.* cap. 2–6, 35–38.

[2] *Rhet.* i. cap. 5.

[3] *Ibid.* i. cap. 9.

[4] *Rhet.* i. cap. 9, αρετη δε εστι μεν δυναμις, ὡς δοκει, ποριστικη αγαθων και φυλακτικη· και δυναμις ευεργετικη πολλων και μεγαλων, και παντων περι παντα.

from the material itself of eloquence, the strong framework of argument, without which no eloquence can subsist. Aristotle, in proceeding to the discussion of style, has cautiously maintained the subordination of this part of rhetoric, to the proper business of the art—persuasion; treating it as a necessary condescension to the weakness of the hearers. If, however, the manner in which we express our thoughts may contribute to the reception of our assertions and arguments,—and it be allowed that the principles of Taste are real parts of the human constitution,—the consideration of style must enter into a philosophical system of rhetoric. The effect of the style is part of the whole result of the composition on the mind of the hearers, and is so far, therefore, an ingredient in that probability about which rhetoric is conversant.

In conformity with this view of the importance of style, Aristotle lays down perspicuity as the great principle of good composition. It is with him "the virtue of style."[1] All the ornaments of language, whether from the structure of periods, or from the various modes of thought by which a point, or a propriety, or a dignity, or an animation, is imparted to a subject, are explained by him in reference to this fundamental law.

Nor has he left unconsidered the arrangement of the parts of a speech; though this also was in his opinion scarcely a legitimate portion of the art. Former rhetoricians had encumbered their systems with numerous artificial divisions, giving precise rules for the composition of each distinct head. Aristotle's more exact method admits no other divisions but the proposition and the proof; the former founded on the necessity of stating the subject of discussion, the latter on the necessity of proving the point stated: though he afterwards allows the convenience of a fourfold division into, 1. the proem or introduction; 2. the proposition; 3. the proof; 4. the epilogue or peroration.

So deeply and fully has the science of rhetoric been considered by Aristotle. His principal treatise on the subject, the *Rhetoric*, in three books, addressed to his disciple Theodectes, and his *Nicomachean Ethics*, are perhaps the most perfect specimens of systematic sciences extant in ancient or modern literature. For extent and variety of matter, the *Rhetoric* may be ranked even above the *Ethics*. It has been justly characterized as "a magazine of intellectual riches. Nothing is left untouched on which rhetoric, in all its branches, has any bearing. His principles are the result of extensive original induction. He sought them, if ever man did seek them, in the living pattern of the human heart. All the recesses and windings of that hidden region he has explored; all its caprices and affections—whatever tends to excite, to ruffle, to amuse, to gratify, or to offend it—have been carefully examined. The reason of these phenomena is demonstrated, the method of creating them is explained. The whole is a text-book of human feeling, a storehouse of taste—an exemplar of condensed and accurate, but uniformly clear and candid, reasoning." It is professedly adapted to the business of the orator, that being the original occasion of an art of rhetoric. But it is in fact a body of precepts for good writing, furnishing authentic principles of criticism in every department of prose composition. His smaller treatise, in one book, entitled *The Rhetoric to Alexander*, is more strictly a science of political eloquence, being written, as the introductory address to Alexander intimates, in obedience to the king, who had requested a work of that description.[2] The same philosophical views of eloquence may be traced in this work; but more popularly set forth, with less of technical precision, and more of apposite illustration from examples.

Poetics.

No work of Aristotle has been more justly estimated than the fragment which has survived to us under the name of his *Poetics*. Imperfect as it is, it has been uniformly regarded as the great authority of the laws of criticism in poetry: subsequent writers having only extended and illustrated the principles laid down in it. The excellence of this little work, which is only one book of the three of which the whole treatise is said to have consisted,[3] shows how much we have to regret the entire loss of other works of Aristotle on the same subject. The treatises *On Tragedies* and *On Poets*, mentioned in the catalogue of Laertius, probably contained much valuable information concerning Greek writers, whose works, perhaps whose names in some instances, have not been transmitted to us.

That portion which time has spared of the *Poetics*, is almost exclusively confined to the consideration of dramatic poetry; but the philosopher, with his usual depth and reach of thought, has here laid a broad foundation of principles applicable to the whole inquiry. He derives the nature of poetry in general from the principle of imitation inherent in man. Two natural causes, he says, appear to have originated poetry; the natural power of imitation,—and the pleasure which all men take in imitation, that is, in recognizing likenesses between distinct objects. These two causes thus stated by him are in fact but one principle: the pleasure resulting from imitation being the principle itself of imitation, viewed in its tendency or proper effect, the production of pleasure; though, in the language of his philosophy, the first would be the motive cause, the second the final. Poetry, then, according to him, is the science by which the natural principle of imitation is realized in its tendency; or a collection of observations on the mode by which pleasure is produced in imitations of which language is the instrument. Hence the business of the poet is stated by Aristotle to consist in representing things, not "as they have been, but as they might be;" and therefore is described by him as of a more philosophical and excellent nature, than that of the historian.[4] The pleasure of imitation will not be answered, unless a likeness be recognized between the objects and events described, and the objects and events of nature: otherwise it will be a mere pleasure in the execution, or in some circumstance of the work. The poet, therefore, in order to accomplish the end of his art, must possess a philosophical power of observation. He must have compared objects and events, and detected points of resemblance, and thus formed for himself general principles on which his imagination may model its ideal world. At the same time he differs from the philosopher very much in the same way in which the orator differs from the dialectician. He has not to consider what is *abstractedly* like in things, but what will be viewed as like in its *effect* on the sentiments and feelings of men. Therefore it is that his creations are clothed with a beauty and loveliness surpassing nature. The resemblances which he shadows out partake of those hues which the wishes of the human heart reflect upon them.[5]

These fundamental notions of the art pervade the sys-

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[1] *Rhet.* iii. 2. *Poetic.* c. 22.
[2] *Rhet. ad Alex.* c. 1.
[3] Du Val's *Aristotle*, ii. p. 82.
[4] *Poet.* c. 9.
[5] *Poetic.* c. 4, 9, 25.

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tem of Aristotle's Poetics, though, from the briefness of the work in its present imperfect state, they are by no means fully developed in it. In the work, indeed, as it now is, the basis of the poetic imitation—the actions, passions, and manners, of which a poem is descriptive—are exclusively considered; and we have no inquiry, as in the Rhetoric, into the principles of human nature by which the pleasure resulting from the imitation is modified in its effect. From this circumstance, as well as from his accounting for the pleasure of poetry on the ground of a natural delight in tracing out resemblances, Aristotle has been sometimes thought to have placed the excellence of a poem in the mechanism of its story,[1] and to have neglected altogether the intrinsic poetry of thought and expression. But we shall not do justice to the comprehensiveness of his views, if we estimate them by the limits of the present work. He seems here to have premised only, what ought naturally to occupy the first place in a philosophical system of the art.

It must be remembered, also, that Greek poetry was essentially dramatic. It was expressly composed with a view to public recitation or exhibition; and in poetry of this kind the character of the incidents would hold a much greater importance than in poetry intended chiefly to be read. The incidents would here hold a place analogous to the thoughts and expressions of the poem submitted to the contemplative study of a reader. This may further account for Aristotle's laying so much stress on the interest of the plot in tragedy.

The definition of tragedy given by Aristotle is remarkable, as savouring more of the spirit of Plato's philosophy than of his own. Describing its nature as it differs from epic poetry and from comedy, he further characterizes it as, "by means of pity and fear, working out the purification of such passions."[2] The purification of the soul was the object to which Plato directed the noble enthusiasm of his philosophy. By converse with the ideas of the intellectual world, he would have the soul disenchanted of the spells which bound it to sensible objects, and cleansed of the impurities of its earthly associations. Aristotle's description of the effect designed in tragedy, applies this doctrine to the particular emotions of the soul produced by pity and fear. His idea appears to be, that tragedy, by presenting the objects of those passions, without the grossness and the violence with which they are attended in actual life, teaches us to feel the passions in that degree only in which an impartial spectator can sympathize with us. By familiarity with these pure abstractions—the true philosophy of the passions so called forth—a moral effect is worked on the heart; the mimic occasions on which it is rightly exercised serving as a real discipline of purification. The question, on what the peculiar pleasure of tragic incident depends, is not distinctly considered by Aristotle. But it may be accounted for on his principles, from the view already given of the purification effected by tragedy, connected with his doctrine, that pleasure is the result of every affection rightly exerted. That moderation of the passions of pity and fear which tragedy has for its aim, is that right exertion of them to which pleasure has been attached by nature, as a consequent.

Practical Philosophy.

Practical Philosophy.

Ethics.

We have observed, that under the head of Practical Philosophy, Aristotle delivers the principles of those sciences by which the goods of human life are attained by individuals or societies. According to this view, the practical sciences are reducible to two: 1. Ethics, by which man is furnished with the principles belonging to his natural good as man; 2. Politics, which inquires into the principles on which the constitution of societies may be made subservient to human good. Economics ought perhaps to be stated as a third branch of science under this head, though, in the view of ancient philosophy, it naturally falls under politics, so far as it concerns the regulation of families: families being regarded as the elements of the political union.[3]

In taking a review of Aristotle's ethical system, it would be injustice to the philosopher to withhold the expression of our admiration of the real wisdom displayed by him in this department of science. We are little aware, living as we do in the sunshine of gospel-truth, what a reach of thought it required, in those times, to see the science of Ethics in its proper light, as a discipline of human character in order to human happiness. The ethical writings of Aristotle, composed amidst the darkness of heathen superstition, abound with pure and just sentiments; and, instead of depressing man to the standard of the existing depraved opinions and manners, tend to elevate him towards the perfection of his nature. They may indeed be studied, not only as an exercise of the intellect, but as a discipline of improvement of the heart; so much is there in them of sound and practical observation on human nature. They are directed, it must be allowed, solely to the improvement of man in this present life; but so just are the principles on which he builds that improvement, that we may readily extend them to those higher views of our nature and condition to which our eyes have been opened. And no greater praise can be given to a work of heathen morality, than to say, as may with truth be said of the ethical writings of Aristotle, that they contain nothing which a Christian may dispense with; no precept of life which is not an element of the Christian character; and that they only fail in elevating the heart and the mind to objects which it needed Divine Wisdom to reveal.

He has left three principal treatises in this department of philosophy, familiarly known by these names: 1. *The Nicomachean Ethics*, or Ethics addressed to his son Nicomachus, in 10 books;[4] 2. *The Magna Moralia*, in 2 books; 3. *The Eudemian Ethics*, or Ethics addressed to Eudemus, in 7 books; besides a short popular tract *On the Virtues and Vices*. *The Nicomachean Ethics* exhibits the most formal and complete development of his theory, and is the work on which his fame as a moral philosopher is chiefly rested. The other treatises are en-

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[1] *Poetic.* c. 6, αρχη μεν ουν και οιον ψυχη ὁ μυθος της τραγῳδιας.

[2] *Ibid.* c. 6, δι' ελεου και φοβου περαινουσα την των τοιουτων παθηματων καθαρσιν. So, again, in his *Politics*, viii. 7, he speaks of "purification" as an effect of music. There he promises to explain his meaning when he comes to treat of poetry; but no explanation occurs in the Poetics.

[3] Theophrastus is considered to be the author of the 1st book of the treatise of *Economics*, edited among the works of Aristotle. (Niebuhr's *Hist. of Rome*, Transl. vol. i. p. 15.) The latter part of that book, indeed, does not pretend to be more than a restoration of the Greek text from a Latin translation. The 2d book is acknowledged to be spurious.

[4] His son Nicomachus has been represented as the author of some of the books of this treatise. Cicero (*De Fin.* v. 2) is inclined to allow him this credit, but without any good reason for such an opinion.

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tirely coincident with this in the views taken of the subjects discussed, and often coincident also in whole passages.

It is well known with what eager but unprofitable subtilty the inquiry into the Chief Good was prosecuted by the Greek philosophers. The speculation proceeded from a misapprehension of the nature of moral philosophy. They thought, consistently with their method in physics, that, as every action of human life appeared the pursuit of some good, there must be some abstract principle of good, the constituent of the moral nature of actions. Hence they were busied in exploring the several objects of human pursuit, and comparing them, and drawing conclusions as to their relative superiority in the order of pursuit. Had they, however, considered sufficiently the subject of their investigation, they would have seen the irrelevancy of any such inquiry to the business of moral philosophy. It was in fact a mere perversion of the terms "good" and "end," which constitute part of the technical phraseology of the science. These notions being once introduced into philosophy, an occasion was furnished for *a priori* speculation into the nature of goods and ends. It is easy to see what a field for ingenuity was opened in determining the point where the two notions coincided; and in this consisted the determination of the chief good,[1] or the *finis bonorum*, as it is expressed by Cicero.

Now Aristotle examined human actions with a more philosophical eye. He readily saw through the vain realism of those speculations which supposed that there was some quality of good admitting of abstract disquisition into its nature.[2] He was aware, also, that when the "ends" of action were spoken of, it was not with reference to some ulterior object, as was implied in all those theories which laid down a speculative definition of the chief good; but that it was the very characteristic of an action, to be *in itself* an end.[3] Hence he was diverted from that track of inquiry which had misled, and which, after him, continued to mislead, other philosophers, and struck out for himself a new path of moral science. He has thrown his preliminary views, indeed, into a form resembling that of the speculative philosophers, in unconscious deference probably to the prejudices of the method in which he had been trained. Thus he sets out in his *Nicomachean Ethics* with a sketch of the chief good and ends of actions, according to his conceptions of its nature: and this is apt to excite an idea, that in reading this work we are only examining a rival system of the same kind with the Greek moral philosophy in general,—an idea which Cicero[4] appears to have formed, since he speaks of Aristotle's having united two objects as together making up the chief good of man. On looking, however, closely into his actual process of investigation, we find it widely different in kind from those inquiries which we have already condemned, the agreement being simply in the technical form of the argument.

The chief good[5] which he is intent on establishing is, the philosophical principle or general nature of actions as such. To describe it more fully,—he investigates the law, according to which, human actions attain the good which is their object, and which, as being the *end* really designed in all actions, whatever may be their immediate particular ends, is the great final cause of all—the end of ends. Aristotle speaks of moral virtue as conversant about affections and actions, περὶ πράξεις καὶ παθη.[6] He discriminates by these terms between external and internal acts—between the works and sentiments of virtue. In strictness, however, actions are the only proper subject of ethical science; which is conversant about human affections, inasmuch as affections are implied in actions. Actions are affections exerted towards some object, and comprehend, accordingly, both external and internal acts. An action, then, according to Aristotle, is good, in which an affection attains its object; and, in that case, the action itself may be regarded as a τέλος or end; the affection being realized, completed, satisfied, in it. Evidently, then, it may be inquired how the affections really obtain their objects in action, or what constitutes an action an end. But this is a very different inquiry from one that, by comparison of particular objects, searches after some definite sole object of pursuit. In this it is presupposed, that every object of a natural affection is an ultimate end, or an object in which that affection, whatever it may be, rests, as in its natural good.[7] Accordingly, it is sought to ascertain how it is so; what that principle is by which any action whatever is really a good in itself and an end. Such a principle is analogous to the chief good of the speculative moralists, because it exhibits human actions in that point of view in which their *goodness* consists, or in which they accomplish that good towards which the affections naturally tend; but it differs so far as it restricts the notion of the chief good to no one distinct class of objects. It is simply a general account of the right constitution of nature exemplified in the multitude of individual instances. As Newton does not inquire what gravity is, but developes the law by which gravity acts; so Aristotle does not give an abstract notion of the chief good, but explores the principle by which it is realized in human life: and thus he obtains a view of it unconnected with any speculative opinions concerning the chief good or happiness of man. His theory leaves the notion of human happiness entirely relative.[8] The philosopher and the uneducated, the rich and the poor, the barbarian and the civilized, each individual, in short, under whatever modifications of human life he may be conceived to exist, must, so far as he obtains the good sought in action, exemplify that law or ultimate principle which constitutes an action a perfect action, or good.

The whole of his several treatises of Ethics consist of a development of this his characteristic view of human good. He had observed how mankind, through the force of passion

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[1] It is not only in speculative systems that we perceive the fallacy with regard to actions considered as goods and ends. Nothing is more common in life than to find actions estimated entirely by a reference to some ultimate good or end which individuals or societies have proposed to themselves, though perhaps not avowedly, as their chief good.

[2] *Eth. Nic.* i. c. 6; *Mag. Mor.* i. c. 1, 2.

[3] *Ibid.* vi. c. 2, 5, x. c. 6; *Polit.* vii. c. 3, 13; Cicero *de Fin.* ii. c. 22, "Id contendimus, ut officii fructus sit ipsum officium."

[4] *De Fin.* ii. c. 6; see also Euseb. *Præp. Evan.* xv. c. 3 and 4.

[5] Laertius mentions, in the Catalogue of Aristotle's writings, a treatise, περὶ τἀγαθοῦ, in 3 books.

[6] *Eth. Nic.* ii. c. 3, 6, 9, &c.

[7] Hence the just compliment to the peripatetic system by Origen (contra *Cels.* p. 10, edit. Spenc.), that it was "the most humane, and candidly acknowledged human goods more than other sects." The Stoics confounded natural and moral good: "quod est bonum omne laudabile est," &c. Cicero *de Fin.* iii. 8.

[8] It is the proper account of the observations of Paley on "human happiness." (*Mor. and Pol. Philosophy*, i. ch. 6.) The various popular views of happiness are well set forth by Aristotle, in *Rhet.* i. 5.

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and evil habits, mistake and pervert their proper goods. Moral philosophy, he thought, might be applied to correct this misapprehension of men—to reform this perversion. The force of reason, at least, might be tried. He wished therefore to propose to their view the real goods intended for them by the constitution of their nature, and to call the attention of each individual to the pursuit of these in his own particular case. His practical design throughout accordingly is, to direct the principles of our moral nature towards their proper objects in such a way that they may rest in these objects as *ends*, and attain the proper good of man. When all the principles are so regulated that this effect takes place in each, the collective result is happiness, or the entire and consummate good of man. Whence he takes occasion to describe happiness in general terms, as in its nature "energy of soul," ψυχης ενεργεια,[1] or "the powers of the soul exerted" "according to that virtue or excellence which most consummates or perfects them." The mode of description is drawn from his physical philosophy. It is founded on a notion of some intrinsic power in the soul working like the operations of the natural world. His theory of happiness, then, contemplates this process of the soul at its termination, where the proper nature of the soul as an *active* principle is fully developed. The truth is, we have then a generalized fact, descriptive of the real state of the case, in the particular instances in which an affection is found to have been happily exerted. He takes, indeed, into his estimate of the chief good, the effect of the circumstances of the world on the virtuous exercise of the powers of the soul; adding the condition of "a perfect life,"[2]—or an adequate duration of human life, and adequate opportunities in the world,—for the development of the moral principles. This, however, is only to assert that the law by which man attains the happiness of his nature, must, in order to be judged of truly, be contemplated in its *tendency*—in the effect that it would produce if it acted freely, without impediment from the world. To think that external goods are causes of happiness, he says, is like imputing the excellence of the music to the lyre rather than to the art of the musician. Prosperity, he also observes, has its limit in reference to happiness, since it may be *excessive*, and in that case would be an *impediment* to happiness.[3] But this necessary qualification of the expression in his sketch of the chief good, gives the appearance of his including prosperity to a certain extent as a *constituent* of the good; whereas in this point, as well as in the whole form of his inquiry into the chief good, he is only following the abstract method of the ancient philosophy. In reality he is pursuing a course of investigation strictly inductive. The terms themselves, "a perfect life," sustain the idea of the soul's working out its own perfection, in which process the perfection of its physical existence would necessarily constitute a part.

Thus, too, the notion of pleasure, considered as an abstract good, is distinctly examined in his Ethics.[4] The practice of ancient philosophy obtruded the question on his notice, whether pleasure was to be identified with happiness, or was to be regarded as an evil. He accordingly formally discusses it; refuting the existing opinions on the subject, and establishing, that pleasure was a good, so far as it necessarily accompanies the exercise of every principle of our nature; and consequently, that the highest pleasures are attached to the exercise of the highest principles. The discussion itself is thrown into a form highly abstruse and speculative; but the conclusion at which he arrives is entirely practical, and of the greatest importance in order to a just theory of virtue. It amounts to this, that the mere gratification of every natural affection, by its exertion in action, is not to be distinctly proposed and aimed at as the end of that affection. This would be to grasp at the result, and neglect the means in order to it.[5] For, the gratification is, as explained by him, the mere *result* of the adaptation of the affection to its object, and *consequent* on the attainment of the object. It is the completion of the process of nature involved in an action.[6] The attainment, therefore, of the highest pleasure attached to our nature, presupposes that the work of virtue has been performed in adjusting the moral and intellectual principles to their objects.

In proceeding to expand this great doctrine, in which his whole ethical system is included, Aristotle appears to have availed himself of the ancient theory of the Pythagoreans, according to which virtue was stated to be ἕξις του δεοντος,[7]—a "habit of propriety or duty,"—or the due internal constitution of our nature. This notion seems at least to have afforded him an outline of his own theory of virtue, though he established it for himself on an extensive basis of original observation. Analyzing our moral nature into affections, capacities, and habits, he at once rejects from the estimate the two former views as inadequate to the effect, and steadily directs his observation to the force of habits in modifying our moral nature. He found that virtuous actions tended to form within us the character of virtue, and that a character so formed enabled us to act virtuously. As it was thus evident that habits were the bond of connection between virtuous principle and virtuous action, he decided that the principle by which the soul worked out its perfection, or, as we should rather express it according to our own ideas, by which the affections of our moral nature were rightly exerted, was in itself a habit.

He had observed also, that, in every instance in which *good* resulted from the exercise of the affections, there was a *due* regard to the personal character of the agent, to the occasion, to the matter in hand, to the persons respected in the action, to the purpose designed, &c.; that thus the virtuous character consisted in an exact adjustment of the internal moral constitution of man to all the circumstances of the world. On the ground, then, of this general fact, he concluded the nature of virtue to be an habitual principle of self-moderation, or, as he expresses it, "a habit influencing the choice, having its being in a relative mean."[8] The abstract mode of ex-

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[1] *Eth. Nic.* i. 7

[2] *Ibid.* i. 7, εν βιῳ τελειῳ; x. 7, λαβουσα μηκος βιου τελειου.

[3] *Ibid.* i. c. 7, vii. 13, x. c. 8; *Eudem.* vi. c. 13; *Polit.* vii. 1 and 13, iv. 11.

[4] *Ibid.* vii. c. 11–14, x. c. 1–5, i. 8; *Mag. Mor.* ii. c. 7.

[5] It may be illustrated thus: In travelling, we may have some place which we desire to reach pointed out to us in the distance; and we may imagine that we shall arrive at it by shaping our course directly towards it, and thus making it our immediate object. But this course would probably lead us into insuperable difficulties; whereas by going along the road leading to it, though that road may be circuitous and indirect, we safely and surely reach it.

[6] Pleasure, accordingly, is defined by Aristotle, in his *Rhetoric*, i. 11, physically, as "a kind of motion of the soul, and a full and perceptible constitution into the proper nature."

[7] Cave, *Opusc. Mythol.*; D. Stewart's *Phil. of Act. and Moral Powers.*

[8] *Eth. Nic.* ii. 6, ἕξις προαιρετικη, εν μεσοτητι ουσα τη προς ἡμας.

pression is a continuation of the same physical notion under which his theory of the chief good is represented. The soul of man is conceived to be wrought to a temperament or mean state, all its affections and actions being in their due proportions.

To determine, however, this due measure of the affections, or this mean to which the constitution of the soul must be brought in order to the virtuous character, is the great question of ethics. To what arbitration shall we resort, to fix the evanescent boundaries of the territory of virtue?

Now, the instances in which this self-moderation belonging to the character of virtue is observed, become in themselves the objects of approbation, exciting in us sentiments of love, esteem, admiration, honour, and commending themselves at the same time to our intellectual perceptions. Hence the various expressions introduced into moral philosophy, of moral fitness, propriety, proportion—the decent, the fair, the honourable, the amiable, in conduct; the adoption of one or more of which tests of the morality of actions, has given its peculiar shade of opinion to different systems. Aristotle contemplates these sentiments of approbation, not as they are in themselves, but as they are outwardly evidenced by the praises of mankind at large accompanying certain actions.[1] It is clear that men praise some actions and censure others. Here, then, is a conclusive evidence of the moral nature of actions. Where men—not any particular society of men, but the wide society of mankind—are unanimous in praising any action,[2] there the quality of praiseworthiness may be imputed to the action itself; or the action is not only "good" in being the attainment of some natural end, but is further in itself the object of approbation. The combination of these two effects is expressed by Aristotle under the term καλον,[3] to which we have no perfect counterpart in our language, though the word "honourable," if understood in its full meaning, may sufficiently represent it.

Aristotle's classification of actions under the heads of different virtues is founded on this analysis of the moral nature of actions. A distinct class of natural objects of desire, to the pursuit of which within certain limits praise is attached, is in his system the ground of a distinct virtue.

His enumeration of the virtues is evidently incomplete. It seems chiefly intended as an evidence by induction, of that moderation of the affections in which he had stated the nature of virtue to consist. His division, indeed, of virtue is physical rather than logical—an enumeration of the *parts* of virtue rather than of the *kinds* of it: and his method, accordingly, did not require of him an exact statement of all the particulars comprized under the general term virtue. He has been accused of attending chiefly to the more splendid virtues. He was very probably led, by the very criterion of virtue which he employed, as well as by his view of the connection between ethics and politics, to sketch more prominently those particular virtues which recommend a man in society. And thus he has drawn beautiful little outlines of those charms of familiar intercourse—affability, frankness, agreeableness.[4] His introduction, indeed, of these qualities among the virtues of his system, is a striking evidence of the practical nature of that virtue which he inculcates. It is a virtue which is not to be forgotten in any part of a man's daily life. Whilst it nerves his arm in dangers, distributes his bounty, shields him against temptations of pleasure, it unbends him in the hours of leisure, and is ever on his tongue, whether gravely pronouncing in his assertions and judgments, or playing in the sallies of his wit. These very instances show that he did not regard splendour as the exclusive attribute of virtue. On the contrary, he expressly speaks of it as only the heightening and decoration of the several virtues, and as meritorious because it presupposes all the virtues in their perfection.[5] Another evidence of his not being exclusive in his regard to the more showy virtues, is his treating of gentleness.[6]

He selects the virtue of justice[7] for more particular discussion. He distinguishes it as a particular virtue from the whole of virtue, which it denotes *relatively*,—in its being the moderation of the love of gain or self-interest. Seduced, however, by the example of Plato, he departs, in his mode of treating this virtue, from the strict province of ethics into that of politics. The justice which he explains is a political virtue, applicable to the citizens of a common state rather than to man as man. And this confusion of ethical and political justice has led him into a speculative refinement, which gives the appearance of a forced effort to reconcile the notion of justice with his theory of virtue. Looking at justice as a dispensing power, he observed that it was concerned about "a mean" in things themselves, apportioning to each person his exact due, whether of reward or punishment. On the ground of this fact he points out that justice is not "a mean," as the other virtues are, but is "of the mean"—not in itself "a relative mean," but "relative to a mean." Had he considered justice solely as a moral habit, he would have seen that the distinction was unnecessary, since in this point of view it conforms precisely to his general notion of virtue in being a principle of self-moderation. There is, however, a foundation for the remark in the circumstance, that justice admits of greater exactness in its exercise than other virtues. "The rules of justice," says an excellent writer,[8] "may be compared to the rules of grammar; the rules of the other virtues to the rules which critics lay down for the attainment of what is sublime and elegant in composition." In the other virtues we are thrown more on our sense of propriety in forming our practical decisions. In justice we have evident facts before us—the merit or demerit of individuals in themselves; and these form an external standard to guide us in our conduct over and above our internal convictions of right. So far, then, justice may be regarded as "of the mean," besides being also a point of propriety, or a mean within ourselves. Aristotle, it should be observed, had no other more appropriate word distinct from "justice" to express "honesty" or "integrity," and consequently was led to generalize too far in his analysis of justice.

Aristotle's discussion of friendship[9] is open to similar objection. He has considered it in its outward effects as a social principle akin to justice, to which justice is subordinate and supplementary, rather than as an internal ethical principle—the moderated exercise of benevolence

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[1] *Eth. Nic.* i. cap. ult., ii. cap. 5, 8, 7; *De Virt. et Vit.* p. 291.

[2] *Ibid.* x. cap. 2, ὁ γαρ πασι δοκει, τουτο ειναι φαμεν.

[3] *Ethic.* passim; *Rhet.* i. cap. 9.

[4] *Eth. Nic.* iv. cap. 6, 7, 8.

[5] *Ibid.* iv. cap. 3, εοικε μεν ουν ἡ μεγαλοψυχια, οἷον κοσμος τις ειναι των αρετων· μειζους γαρ αυτας ποιει, και ου γινεται ανευ εκεινων· δια τουτο χαλεπον τῃ αληθειᾳ μεγαλοψυχον ειναι· ου γαρ οἷον τε ανευ καλοκἀγαθιας.

[6] *Ibid.* iv. cap. 5.

[7] Among his lost treatises was one *on Justice*, in 4 books. (Diog. Laert.)

[8] Adam Smith, *Theor. of Mor. Sentim.* part iii. chap. 6.

[9] *Eth. Nic.* viii. ix.

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in the heart itself. His observations, however, on the subject admirably illustrate the importance of friendship to the right constitution of society—the various modifications of the benevolent principle in the different relations of human life—together with the peculiar amiableness of virtue in itself. In the last respect, indeed, the discussion forms an essential part of his moral philosophy, as it tends to show his conviction that the moral principles have their seat in the heart.

Indeed, this part of his Ethics, as well as his inquiry into justice, should be accurately studied by all who would obtain just views of the comprehensive character of the virtue of his system. Together they comprize a body of relative duties. Under justice would be classed the duties of "religion, memory of the dead, filial reverence, patriotism, civil obedience, veracity, honesty," &c.[1] so far as these duties flow from *claims* on our respect, and are prescribed by human laws: under friendship, the same duties as they are prompted by sentiment and feeling, and are known by the names of piety, gratitude, benevolence, fidelity, generosity, &c. Hence his beautiful summary of the character of virtue, when he says, that "it is of virtue both to benefit the worthy and to love the good; and to be neither apt to punish nor revengeful, but merciful, and placable, and indulgent; and there follow on virtue, kindness, equity, candour, good hope; moreover, such qualities as, to be domestic, friendly, social, hospitable, philanthropic, and a lover of what is honourable."[2]

His theory, then, of virtue must be regarded as involving a minute and distinct attention to all the particular virtues. And herein appears its great excellence, as contrasted with those of some modern philosophers, who have endeavoured to trace up all the virtues to some one principle of our nature, as benevolence, or self-love, or prudence. All such theories are in truth mere accommodations of language, by which different classes of phenomena are arranged under the same terms; and they tend rather to give a shadowiness to the form of virtue, instead of striking it out in bold outline. Aristotle's theory is the law by which these different classes of facts are held together in fact, the common process by which the operation of each virtue is carried on; and which, when realized in the character of a man, gives him the command of all the virtues.

The ancient moral philosophy sought, like the modern, to resolve virtue into some *one* principle; but the endeavour of the ancients was rather to ground it on some *intellectual* principle. Socrates contended that the virtues were instances of prudence or knowledge, φρονησεις, or λογοι, or επιστημαι. Aristotle shows the foundation of this misconception, in explaining in what respect the production of virtue might be regarded as the work of the intellect. Each virtue consisting in the adjustment of the action to all the circumstances of the case, the virtue of each action must consequently depend on the practical judgment of the individual agent; and an agent who is uniformly virtuous must exhibit this practical judgment uniformly operating, enabling him to decide on the point in which the virtue of acting lies.[3] This operation of the intellect on moral objects he designates as the intellectual virtue of prudence or wisdom.[4] He speaks of it as "defining" or bounding the mean in which virtue consists;[5] that is, as a speculative definition presents to the mind an exact notion of the thing defined, so the principles supplied by prudence give us a perception of the moral nature of an action. For example, suppose a man to have received some evident wrong—some injury done to him without provocation. The affection of resentment naturally leads him to requite the injustice on his assailant; but by what method of action he should do so, is a matter of question. He must know exactly in what way his resentment should be shown, in order to act virtuously; besides having as his general principle, the inclination to act virtuously.[6] He must, therefore, have had some experience of human life—some practical knowledge of the nature of actions which have been approved as fulfilling the end of this affection. An experience, then, of this kind, applied to the exercise of all the affections, and operating invariably on the conduct, constitutes the prudence of Aristotle's system. It is thus intimately connected with the moral principles, as the moral principles are with it. It is the combined result, in the intellectual part of our nature, of all the virtues of the heart; as, on the other hand, prudence is the diverging of the intellect through the various virtues of the heart. Hence his conclusion, that it is impossible to be properly good—κυριως αγαθον—without prudence, or to be prudent without moral virtue; and consequently, that all the moral virtues are inseparable, inasmuch as the possession of all is requisite for the perfecting of prudence.[7]

In this account of prudence is to be traced the principle of moral obligation involved in Aristotle's theory of virtue. He considers the moral virtues as those of the inferior part of the soul, and therefore as formed to obey; whereas the intellectual principles, as being purely rational, had in their nature an intrinsic authority. Prudence, accordingly, being the intellectual virtue employed in conjunction with the moral in the production of virtue, is, from its nature, supreme over its associated principles, and demands of right their submission to its dictates.[8] It must be confessed that such a ground of obligation is merely theoretic; and so Aristotle himself perceived it to be.[9] As a principle of observation and reflection, it resembles in some measure the supremacy of conscience; but it does not come up to the force of that master-principle. Conscience rewards and punishes by its judgments, whereas the dictates of prudence carry no such sanction in them. Properly, however, the notion of "obligation" is inapplicable to his system. Not inculcating morality as a law, but as a philosophy, or art of life, he was not called upon to show why it should be *obeyed* as a law. It was enough for him to point out, from observations on human conduct, that it is *in fact* obeyed by all who attain their real good.

But though the principle of conscience has no place in his theory, it is certainly implied in his test of virtue and vice—the praise and blame of mankind. The universal consent of mankind on these points he considers as decisive of the moral nature of an action. But this is to allow a standard of right and wrong inherent in human nature, or what is equivalent to a conscience. If all agree in praising a certain modification of the affections, and in blaming another, it is clear that there must be some common principles in all to serve as the bases of these unanimous judgments. The same conclusion results from his admission of capacities of virtue, and of the existence of natural virtue, in man, antecedent to the

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[1] *De Virtut. et Vit.*
[2] *De Virt. et Vit.* p. 296, Du Val.
[3] *Polit.* vii. 13.
[4] Σοφια means Philosophy rather than what we understand by wisdom.
[5] *Eth. Nic.* ii. 6, ὡρισμενῃ λογῳ, και ὡς αν ὁ φρονιμος ὁρισειε.
[6] *Mag. Mor.* ii. c. 7; *Eth. Nic.*
[7] *Eth. Nic.* vi. c. 13, x. c. 8; *Eud.* v. c. 12.
[8] *Eth. Nic.* i. c. 13, iii. c. 12; *Polit.* viii. c. 14.
[9] *Eth. Nic.* x. c. 9.

proper formation of it in the character. Indeed, his analysis of prudence is in itself decisive of his real view of this point. Not only are the principles on which prudence is to speculate to be drawn from the heart; but the very deduction of these principles to the particular cases of conduct involves moral perceptions. For how else is the precise point in which the mean lies—in which the due measure of the affection exerted consists—to be ascertained? If the virtue of the action consisted in an absolute mean, a mere intellectual process, such as that of arithmetic or geometry, would enable us to ascertain it. But the mean in question being neither more nor less than what is *proper*, this implies a sense of propriety. Right conduct, according to him, is not such because it is neither excessive nor defective; but it is neither excessive nor defective because it is right. This is plain from his induction of the several virtues, in which he shows that there is a mean, because there is a point of propriety; so that a moral perception must precede every decision on moral questions. It is of the greatest consequence, in order to a right understanding of his account of virtue, to observe this necessary dependence of the knowledge of the mean, on the adjustment of the moral principles to their objects. The want of attention to it has led to absurd objections against Aristotle's theory. He has been interpreted as if he had said that we could have *too much* courage, *too much* liberality, &c.; which notion proceeds on the false assumption, that the mean laid down by Aristotle is a *quantity;* whereas it is only a proportion or correspondence existing between the principles of the agent and the objects of those principles.[1] The term "mean," in fact, as employed by Aristotle, is merely negative, marking the exclusion of all unchastened feeling from the character of virtue.

But though his system is defective as an authoritative law, it developes a much nobler theory of duty than the philosophy which rests our obligation to virtue on a ground of interest. The "prudence" of Aristotle's ethics must be understood as widely different from the prudence of such a theory. The prudence which he teaches is no calculation of consequences. It is a practical philosophy of the heart, inseparably connected with the love of that conduct which it suggests: whereas, when we are taught to act on the ground of interest, the prudence then inculcated is a mere intellectual foresight of consequences, independent of any exercise of the heart.[2] Such a system, whilst it overthrows the distinction between right and wrong as a fundamental principle, requires either a very comprehensive power of intellect in order to its practical adoption, or an express revelation from the Deity, declaring the good and evil consequences annexed to actions. These are conditions which sufficiently expose its futility as a guide to duty. The heart of man leaves far behind this morality of consequences, and decides, even before the action itself has its birth, whether it is morally right or wrong. The appeal to the revealed will of the Deity is not only a *petitio principii*, inasmuch as no will of the Deity can be ascertained and proved divine, without the previous admission of principles of right and wrong; but is refuted by the simple fact, that theories of virtue such as that of Aristotle have been devised by men who had no belief in a Divine Providence. We speak not of the excellence of such theories, but of the mere fact of their *existence* as accounts of human duties. That "the difference, and the only difference," between an act of prudence and an act of duty is, "that, in the one case, we consider what we shall gain or lose in the present world—in the other case we consider also what we shall gain or lose in the world to come;"[3]—is an assertion disproved at once by the fact, that Aristotle saw a difference between the two acts, independently of that consideration on which the notion of duty is there made to rest. Whether he has stated the difference correctly or not, is immaterial to this point.

The principle of self-love has also been well illustrated by Aristotle in its relation to virtue. He distinguishes between the culpable form of it, or selfishness, and that form of it which is auxiliary to virtue. Self-love, then, in its good sense, may be acted on by the virtuous man, whose character is already framed on the principle of "the honourable;" and in that case, he shows, it will be coincident with benevolence; since the person so pursuing his own interest will also effectually promote that of others. But this is not the case with the bad man; since, in pursuit of his views of self-interest, the bad man will at once injure himself and others by compliance with bad passions.[4] It is evident from the above, that neither does he admit of benevolence being made a principle of conduct, otherwise than as a proper benevolence pre-supposes other moral principles, and is regulated consequently in its exercise by a prevailing regard to the "honourable" or right. He has also enforced his primary notions of duty by pointing out the proper amiableness of virtue, both as the only sure tie of attachment between man and man,[5] and as the only thing which produces tranquillity, self-satisfaction, and delight, in a man's own bosom. On the latter point, indeed, he speaks almost in terms descriptive of the joys and pangs of conscience.[6] So justly has he embraced in his view the most powerful auxiliary principles, without exalting them, as some philosophers have, to an undue place, by making the theory of virtue to rest on them.

Such, then, is that account of virtue which Aristotle's practical philosophy developes. He delivers it as the theory of perfect conduct, as that which is exemplified in operation whenever human good is realized in life. It is at the same time, it should be observed, an account of the nature of virtue, and of the internal process of our own constitution, by which virtue is produced. The affections being all habitually moderated by prudence, virtue is the result; and in that moderation consists the nature of virtue.

He was not, however, inattentive to the fact, that the speculative perfection of a practical rule is not realized in human life. He was aware that a complete subordination of the affections to the principle of prudence was a task of difficulty above the efforts of man as he is. So also his view of vice, as that state of man in which his principles are entirely corrupted,[7]—the affections being conformed to evil, so that he continually and insensi-

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[1] *Eudem.* iii. cap. 7; *Eth. Nic.* ii. cap. 6, ὁ μητε πλεοναζει, μητε ελλειπει, του δεοντος—στοχαστικη γε ουσα του μεσου.

[2] A moral philosophy of this kind is in fact a revival in a new form of the theory of Socrates, which made virtue a science. It overlooks the affections in the production of virtue, as the theory of Socrates did.

[3] Paley's *Mor. and Pol. Philos.* book ii. chap. 3.

[4] *Eth. Nic.* vol. ix. cap. 8; *Mag. Mor.* ii. 13, 14; *Polit.* ii. 3.

[5] See Bishop Butler, *Serm.* i.

[6] *Eth. Nic.* ix. cap. 4, Ει δη το ουτως εχειν λιαν εστιν αθλιον, φευκτεον την μοχθηριαν διατεταμενως, και πειρατεον επιεικη ειναι· ουτω γαρ και προς αυτον φιλικως αν εχοι, και ἑτερων φιλος γενοιτο. *Eudem.* vii. cap. 6.

[7] *Eth. Nic.* vii. cap. 8, Η γαρ αρετη και μοχθηρια την αρχην, ἡ μεν φθειρει, ἡ δε σωζει; vi. 5, Εστι γαρ ἡ κακια φθαρτικη αρχης.

Practical Philosophy.

bly[1] chooses evil rather than good,[2]—is a philosophical limit of the extent of human depravity, and not an account of vice as it actually exists in the world.[3] It is indeed a just conclusion, from experience of that degradation to which our nature is brought—that hardening of the heart, as the Scripture terms it, by the habitual violation of our duty. As the end, therefore, as the perfect form of vice, this state of the heart should be sketched out by the moralist, to give their proper practical cogency to his admonitions. His outlines of virtue must be drawn from virtue realized in its tendency—from that condition of it in which it is the attainment of man's chief good; as vice, on the other hand, must be contemplated where it stands fully confessed as man's chief evil. There may be a virtue above our nature, as there may be a vice below it; and Aristotle notices both these extremes: but neither of these presents a standard of human excellence or human depravity, and therefore requires no distinct consideration in an ethical treatise. But the actual virtues and vices of men, as they are observed in the world, exhibit an endless variety of modifications within the theoretic limits of virtue and vice. The affections are more or less brought into subjection to the rational principle in different individuals; and men are praised and blamed in proportion as they have established this command over themselves, or have lost it. And hence a secondary or inferior kind of virtue results, as well as a less odious vice. As it is in the indulgence of the sensual affections that human frailty is most seen, Aristotle distinguishes this secondary virtue and vice by contrast with the particular virtue and vice of temperance and intemperance; as if they were simply what we express by continence and incontinence; but his distinction of their nature is a general one, and belongs to the whole character of virtue and vice.[4] But in admitting a morality of this nature, he laboured under a speculative difficulty. Socrates had denied the existence of any such imperfect vice, on the ground that the virtues were sciences, and that it was impossible for a man to act against his convictions of the best. Aristotle, though not agreeing with Socrates in regarding the virtues as sciences,[5] still, as he admitted an intellectual process in the production of virtue, felt himself required to explain how this higher principle was overpowered by the weaker, as it evidently was in the incontinent man. In the course of this explanation he has touched on the true philosophy of those facts in which the principles and practice of men are evidenced at variance. He has accounted in some measure for the apparent anomaly of the same person exhibiting at different periods such contrasts of character—at one time commanding the passions, at another yielding to them. For he delineates, it should be observed, under the characters of "the continent" and "incontinent," not two different persons, as in the case of "the temperate" and "intemperate," but what will usually be the same person at alternate intervals, since no one can very long remain either.

The question of the freedom of the will has been admirably treated by Aristotle. It is discussed as it ought to be in a treatise of moral philosophy, independently of those metaphysical difficulties with which it is commonly overlaid. What the nature of human will is, whether it must be regarded as free or necessary, according to our abstract notions of liberty or necessity, forms no part of his inquiry. He points out simply, what are the classes of actions in which an agent is generally held *not* responsible for his conduct; and excluding these, decides on the remainder—that, since in these, men *are* held responsible; as is shown by the praise and blame, reward and punishment, attaching to their conduct; there, the actions are voluntary. This is the extent to which the inquiry, so far as it is strictly ethical, ought to be carried. Whether we speculatively conclude the will of man to be free or necessary, *practically* we must proceed *as if* it were free; since to act on that supposition accords with the facts of human life: whereas, to act on the theory that we are under a necessity, would lead us against the common practice of mankind, by which we are treated as responsible. Aristotle indeed argues, that though the question be decided in the negative, it leaves the relative nature of virtue and vice on the same footing; if our virtues may still be imputed to us, so may our vices.[6] But he more distinctly affirms the *voluntary* nature both of virtue and vice, on the ground that the αρχη, the principle of the action, is εφ' ἡμιν,—in ourselves—in our own power. Thus, though the virtuous or vicious habits that we have formed may dispose us to a particular course of behaviour, so that, as being under their influence, we cannot act otherwise, yet the actions so performed are voluntary; because it was in our power to do or forbear that course of conduct which led to the settled habit.

The principle thus described as "in ourselves," is, in Aristotle's philosophy, the *motive* of our actions. It is that from which the *effect* on our conduct has originated; and it comes therefore under that class of principles which we have described as constituting the motive or efficient cause. The term "motive," however, is sometimes transferred in popular use to the object or end of an action;[7] which being something external to ourselves, gives occasion to question the voluntary nature of actions. But, in strictness, the *end* chosen by the agent or object at which he aims, is in itself no cause whatever of his *acting*, but rather the cause of the morality or immorality of his actions, or what constitutes their moral nature.[8]

But the principles employed in the production of moral virtue are not the whole of our internal nature, nor are they the highest principles. And Aristotle's theory implies the exertion of all, and, if there be a relative su-

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[1] *Eth. Nic.* vii. cap. 9, ἡ μεν γαρ κακια λανθανει. *Rhet.* ii. 4, τα δε μαλιστα κακα, ἡκιστα αισθητα, αδικια και αφροσυνη. This insensibility is the result of confirmed habit; and the same result takes place in regard to virtue. The moral principles are less felt, as mere internal principles, when perfected in the character; operating as it were without thought or effort, in the conduct. See Bishop Butler's *Analogy*, chapter on Moral Discipline.

[2] *Ibid.* vii. cap. 8, Ὅτι μεν ουν κακια ἡ ακρασια ουκ εστι, φανερον· αλλα πῃ ισως· το μεν γαρ παρα προαιρεσιν, το δε κατα προαιρεσιν εστιν.

[3] *Ibid.* iv. cap. 5, Ου μην ἁπαντα γε τῳ αυτῳ ὑπαρχει· ου γαρ αν δυναιτο ειναι· το γαρ κακον και αὐτο απολλυσι, καν ὁλοκληρον ῃ, αφορητον γινεται.

[4] *Eth. Nic.* vii. c. 7; *Eudem.* vi.; *Eudem.* iii. c. 11.

[5] *Eudem.* vii. c. 13; *Eth. Nic.* vii. c. 3.

[6] *Eth. Nic.* iii. c. 1, 5; which is in substance the conclusion of Bishop Butler (*Anal.* p. 1. chap. on the *Opinion of Necessity*). The whole doctrine of this chapter is coincident with the views of Aristotle, and illustrative of them.

[7] Paley speaks of "private happiness" as "our motive." (*Mor. and Pol. Phil.* b. ii. c. 3.) We use the term in the Aristotelian sense when we say that ambition or avarice is a person's motive, but not in saying that power or self-interest is so.

[8] *Eth. Nic.* vi. c. 2; *Eudem.* iii. c. 11; *Metaph.* vi. c. 1.

periority among them, a preference of the higher. He assigns, accordingly, the greatest happiness to the exertion of the intellectual principles. These he had already analyzed, in tracing the connection of the intellect with virtue; and, dividing them according to the classes of objects on which they are exercised, had assigned the pre-eminence to Σοφια, or philosophy, the science of the highest objects.

That a philosopher, living, as Aristotle did, amidst the disorder and misery occasioned by the want of a true and practical religion, should have sought for a perfection of happiness out of the troubled scene in which moral virtue is disciplined, ought not to excite our wonder. The calm regions of philosophical contemplation—*sapientum templa serena*—presented a natural refuge to the anxious mind, eager to realize its own abstractions in some perfect form of human life. There, those principles which his theory had sketched, appeared to hold without exception; and those uncertainties and limitations which elsewhere attended their operation, either to vanish or to be greatly diminished. It was a search, indeed, after that happiness which revelation has made known to us,—a happiness out of our present sphere of exertion and duty,—in which man might obtain the full end or consummate good of his being. Aristotle himself describes the pursuit of this ulterior happiness in terms indicative of this; as an immortalizing of our nature; as a living according to what is divine in man; as what renders a man most dear to the Divinity, most god-like.[1] From not believing, however, any doctrine of the real immortality of man as a compound being,—though he held a partial immortality of the soul, that of the intellect,—he determined the excellence of human happiness from a view of the *present* condition only of man.[2] In this exclusive point of view, the intellectual virtues would be justly entitled to the pre-eminence, though experience convinces us that even these are not without their alloy.[3] He by no means, however, regards the exercise of these virtues an exemption from the necessity of cultivating the moral. To enjoy the happiness of the theoretic life is the highest privilege of our nature; but still our condition as men[4] calls to the exercise of those virtues from which our proper happiness as men, as compound beings consisting of passions and intellect, and living in an evil world, results. No philosophy but that of Aristotle has maintained this proposition. Plato would lead his followers into the indolent reveries of mysticism; the Stoics would reduce theirs to indifference about human things; the Epicureans would absorb theirs in the fulness of present delights; Cicero would degrade the higher employment of the soul in the contemplative life below the ordinary moral duties, confounding the *dignity* and the *indispensableness* of an employment. But Aristotle directs us to pursue that happiness which is beyond our attainment as compound beings, at the same time whilst we actively exert ourselves in the discharge of those duties which belong to us as men.

Politics.

The observed inefficiency of ethical precepts in themselves to produce morality in the lives of men, and the consequent appeal to some external sanction for their enforcement, led to such works among the ancients as the Politics of Aristotle. The Christian observes the same fact, and draws from it a strong argument for the necessity of a divine revelation. Aristotle and other Greek philosophers looked to the influence of education directed by civil laws and institutions, and to the rewards and punishments of civil government, as the great instruments for bringing mankind to that course of action in which their real interest consisted.

Aristotle was induced to ascribe this moral force to the law of the state, through the current notion of ancient philosophy, which confounded moral and political good. The good of man as an individual was conceived perfectly coincident with his good as a member of society; and the science of politics, therefore, was supposed to include under it that of ethics. Had not these philosophers been misled by the abstract terms "good" and "expedient," they could hardly have thus blended together the heterogeneous objects of moral and political science. They would have seen that the social union is inadequate to the promotion of that good of man which results from his internal nature, and that it could reach no further than to the protection of the individual from external aggression on his person and property, and allowing him the unobstructed exercise of his virtue. "Civil government," says Bishop Butler, "can by no means take cognizance of every work which is good or evil; many things are done in secret, the authors unknown to it, and often the things themselves; then it cannot so much consider actions under the view of their being *morally* good or evil, as under the view of their being mischievous or beneficial to society; nor can it in any wise execute *judgment* in rewarding what is *good*, as it can, and ought, and does, in punishing what is *evil*."

In consequence of this mistaken view of the end of the social union, the ancient political philosophy was not a system of jurisprudence so much as a speculation concerning the most perfect form of government,—theories of social happiness, rather than the principles of laws by which the relative rights of men might be maintained. Ingenious men amused themselves with fancying how society might be modelled, so as to exhibit that ideal optimism which they had pictured to themselves; instead of attending to the real phenomena of human life, and deducing from them the right administration of society under its actually existing forms.[5]

Aristotle, in common with other Greek philosophers, constructed a theory of politics on this delusive principle. Proposing to himself the perfect polity, as that in which the virtue and happiness of the man and the citizen exactly coincide, he proceeds to sketch out the form of it, and thus to obtain an outline of the institutions on which his ethical system must practically depend for its support. But he was not, like other philosophers, so fascinated by theory as to overlook the practical nature of the science. He complains of his predecessors, that however well they might have treated the subject in other respects, they had at least failed in the useful. They had contented themselves with devising forms of polity which could only be effected with a concurrence of every favourable circumstance, whereas the practical usefulness of the science required the delivery of principles applicable to the improvement and security of existing governments. We know, indeed, from the titles of other works on politics which he is said to have written, *the Polities of One Hundred and Fifty-eight States*, the four books *On Laws*, and

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[1] *Eth. Nic.* x. c. 7 and 8.

[2] *Eth. Nic.* x. c. 8. αἱ δὲ τοῦ συνθέτου αἱρεταὶ ἀνθρωπίκαι, κ. τ. λ.

[3] See Bishop Butler's Sermon *On the Ignorance of Man.*

[4] Πρὸς τὸ ἀνθρωπεύεσθαι, *Eth. Nic.* x. c. 8.

[5] Draco, however, and Pittacus, were only framers of laws, and not of polities. (Aristot. *Polit.* ii. c. *ult.*)

Practical Philosophy.

the two books *On the Politician*,[1] that he did not consider the subject as exhausted in the theory of a perfect polity. The observations, too, on justice and on civil policy, contained in his Ethics and Rhetoric, are proofs of the practical views with which he contemplated the subject: and even in the work now before us, which developes his professed theory of politics, the substance of the inquiry is, sound and enlightened instructions of policy, drawn from experience of human nature, and applicable to all times and circumstances. From its connection with his Ethics, it was intended in fact to be applied by each individual in the practical business of education. He wished the individual to obtain by means of it that scientific knowledge of the effects of institution and discipline on the human character, which might assist him in the treatment of the particular cases of his own actual experience.[2] It thus harmonized completely with his Ethics, the object of which was, as before stated (p. 519–20), to enable each man more effectually to realize his own particular good by a general knowledge of what was good for the species at large.

The perfect polity sketched by Aristotle is a theory of the end to which man, viewed in his social capacity, at its best estate, and unimpeded by external obstacles, may be conceived to tend. It is a view of the end or τελος in his political system, corresponding to his account of the chief good in his Ethics. He arrives at it by the same train of thought which led him to his account of the chief good. He considered, first, that man, independently of any calculations of expediency, was naturally a political animal;[3] as in his Ethics he assumes that man is endued by nature with active principles tending to his own good. He admits that expediency is instrumental in cementing the union among men, but does not rest society on this principle; wisely judging that man is induced originally to associate with man by various internal principles of his nature, and not simply by motives derived from reflection on his wants, which last are in truth only secondary causes, and auxiliary to the former, in like manner as the principle of self-love is auxiliary to the natural affections on which virtue is founded. As, then, in his Ethics he went on to inquire what principle rendered actions perfect, exhibiting them attaining the end for which nature had constituted the affections, and as this principle formed the chief good of his ethical system, so in his Politics he carries on his view of the social nature of man to the point where the union to which it tends appears self-sufficient and perfect. The mode in which the social principles might be found to operate in this ultimate case would present the perfection of social virtue; and from this specimen of social virtue would be deducible, right forms of government, institutions, and laws, just as the several rules of right moral conduct are drawn from the whole moral nature of man contemplated in its perfection.

To put ourselves, accordingly, into that posture of mind in which Aristotle appears to have contemplated the subject, we must suppose the case of a society analogous to that of an individual. The analogy between the principles of the heart, as a constitution or system of related principles tending to a common end, and the elements of a political community, could not but be familiar to the mind of a disciple of Plato, who delighted in drawing his outlines of moral virtue from the imagery of social life. But Aristotle, though sometimes imitating the beautiful language of Plato in his ethical descriptions, has inverted the analogy, and framed his representation of a perfect society after the resemblance of the internal constitution of the heart. We must imagine, then, the various members of a community, when brought to the standard of perfection implied in the notion of a perfect constitution, all obtaining their respective dues in a manner analogous to the due moderation of the affections in the virtuous character. A "mean" is to be attained in the one case as in the other.

Agreeably to this view of his mode of speculation on the subject, Aristotle describes the perfect polity as a mixture of oligarchy and democracy, as a state which appears both these forms of government, and neither of them; in which no one of the component elements of society has a preponderance, but the claims of freedom, of wealth, and of virtue,[4] are all duly considered. A form of government which is thus a "mean" throughout, Aristotle designates by the name of "Polity;" appropriating to it the general name, and thus distinguishing it as the perfect form, the proper constitution of a πολις, or city,—a city being the "end" of the social union.

If, indeed, not mere protection from mutual injury, but the promotion of virtue, were the object of the social union, as Aristotle contends, it must be allowed that that only can be a perfect constitution of society in which the standard of political rights is the same with that of moral right. In this ultimate perfect form, upon such a supposition, the science of politics becomes absorbed in that of ethics. The community in this case acts as the dispenser of the laws of morality; and its honours and its penalties are but the channels through which virtue works its own rewards of happiness, and vice its own punishments of misery.[5] But this is, as we contend, on the other hand, to intrude on a province far beyond that of political science. Schemes for the moral perfection of society belong to the wisdom of a providence more than human, working good out of evil, and, from a boundless survey of all the relations of things, accomplishing important results by means apparently incompetent. Man, in his designs of moral good, has only to attend closely to the mechanism placed under his observation—to use the appointed means—to cultivate given powers—to provide against foreseen consequences—and then trust that the happiness, which must surely be the end of the whole under a wise and good Providence, will be the result of his well-ordered exertions. Thus, it is manifest to our view, that from the ungoverned passions of men evil will ensue. Society, therefore, may lawfully be employed as an instrument for preventing this misery, so far as external means can reach it; and so far, too, it may encourage virtue, and indirectly promote human happiness.[6] But let it propose to itself "what is best" as the distinct aim of its constitution, and it bewilders itself with theorics, no one of which will in any probability realize its plausible expectations; whilst, on the contrary, some evil must certainly ensue from artificial attempts on so large a scale. For it is impossible,

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[1] These works are mentioned by Diogenes Laertius. A portion of the *Polities of One Hundred and Fifty-eight States*, relative to the constitution of Athens, has been preserved by Julius Pollux.

[2] *Eth. Nic.* x. c. *ult.*

[3] *Polit.* i. 2, iii. 6.

[4] Nobility, according to Aristotle, is "ancient wealth and virtue;" or "the virtue and wealth of ancestors;" and does not, in his view, therefore, form a distinct head of claims. According to Laertius, he wrote an express treatise, Περὶ Ευγενειας, in one book.

[5] Bishop Butler's picture of a perfectly virtuous kingdom will readily occur here. (*Analogy*, part i. chap. 3.)

[6] *Polit.* i. cap. 2, Φυσει μεν ουν ἡ ὁρμη, κ. τ. λ.

as Aristotle himself well observes, but that, "from false good in the outset, real evil must at length result."[1] Aristotle, however, is justifiable in point of consistency here, with the rest of his philosophy. Excluding from the course of nature a providence distinct from nature itself, he proceeded, according to his system, to attribute an internal self-adjusting power to society considered as an effect of nature. The maxim, that "Nature does nothing in vain," is at the base of his moral and political philosophy, as well as of his physical. The perfect polity is an illustration of this maxim. It is the perfecting of the self-provisions of nature in the human species.

The real excellence, however, of Aristotle's theory of the perfect polity consists in this, that if we admit a Divine Providence, to whose foresight we ascribe the final cause or ultimate tendency of the social union, it is a negative description of the policy which should be pursued in every well-constituted state. It points out the manner in which the public welfare must be sought; that is, by not making any one of the objects commonly pursued in the political world the express object of pursuit to the community. On the hypothesis, that the happiness of the world is the care of Him who ordered it, every society should be so constituted as that no appointment of Providence be overlooked, but every part of the social machinery be brought into action. The love of conquest, for instance, will not be the aim of such a state. Such a policy would employ its military resources only, to the exclusion of its other materials of happiness. Aristotle particularly points out this in the instance of Lacedemon, whose whole policy was framed for war; whereas, as he observes, a state should be adapted for living well in peace, and enjoying that repose which is the end of its engaging in war.[2] Nor, again, will the mere accumulation of wealth be the express aim of the state in its whole policy. Such a ruling principle would tend to degrade the great mass of the population, and to undo the very connection itself between the members of the community, by pushing the boundaries between the rich and poor to the extremes of opulence and pauperism; of which condition of things the natural result is the tyranny of an oligarchy. Lastly, if even liberty is made the exclusive aim of state policy, unhappiness is the sure result. Whilst the members of the community grasp at an unrestrained licentiousness, they disregard the various gradations of society, by which the sphere of human duties is enlarged, and the greatest securities against violations of liberty are provided; and thus a wild democracy usurps the place of a just polity. Now, Aristotle's theory excludes all such gross schemes of policy. It admits only the general pursuit of the public welfare; which, like the private happiness sketched in his Ethics, is not to be made a *distinct* object under any particular form, but must be the *general* pursuit of the *whole* organization of the society; as private happiness is the *result* of the general regulation of all the moral principles. It is true that he supposes a society to constitute itself in order to its own moral happiness; and herein is the defect of his theory. But if it be considered that this was a necessary substitute in his system for a Divine Providence, his theory, it will be concluded, did not imply that the individual members of the community should expressly propose to themselves, as their object of pursuit, that happiness to which the social system itself should tend. It was evidently to be brought about by that mysterious agency which, from not admitting a real Providence, he was compelled to ascribe to nature.

This is further illustrated in his description of the three right forms of government, and the three improper or deviations from the former. He admits that the public welfare may be promoted under other forms—under a monarchy or an aristocracy, as well as under "a polity." These three forms are indeed coincident in principle, according to Aristotle, being variations produced by differences in the character of the people among whom they arise.[3] The perfect "polity" presupposes an equality among the members of the society,—that all are capable in turn of governing, as well as of being governed. But there may in some cases be marked differences between a family, or an individual, or a class of individuals, and the bulk of the people; and in these cases the rule of justice requires that there should exist in the first a monarchy, in the latter an aristocracy. So far, indeed, does Aristotle carry this principle as to say, that any single person eminent in worth above the rest of the community, as one of a more divine nature, ought to have entire obedience from the rest, and to be perpetual sovereign.[4] The three forms, then, of monarchy, aristocracy, and polity, are right; because, being founded on the relative merit of the members of each society, and the standard of merit being virtue, the rule of justice is maintained in them. The public good follows, therefore, not from the ascendancy of this or that principle of policy in the government in each case, but from a due regard to all the subsisting relations in the state. But in the corresponding perversions of these right polities—in a tyranny, an oligarchy, and a democracy—particular principles prevail, and particular interests, accordingly, are consulted, to the violation of justice and the sacrifice of public good.

Aristotle appears the only political theorist among the ancients who never lost sight of the moral nature of man in his speculations. The systems of other theorists, as Plato, Phaleas of Chalcedon, Hippodamus of Miletus, and the polities of Lacedemon, Crete, and Carthage, for the most part treated human society merely as a physical mass, capable of being moulded into particular forms by the mechanism of external circumstances. Aristotle, on the contrary, lays the chief stress on the force of "customs, philosophy, and laws,"[5] for producing the best constitution of society. Still as, in his Ethics, in order to the development of his theory of the chief good of man, he supposes a condition of human life adequate to the exercise of the moral powers; so, in his Politics, he supposes a concurrence of circumstances favourable to the existence of the perfect polity.[6] In this theory, as in that, there must be no impediment from without to the operation of the principles. Here, as in the Ethics, the production of the desired effect is the combination of three principles—nature, custom, reason.[7] Therefore, also, as there must be certain elements of virtue in the heart in order to the moral improvement of an individual, so there must be the proper elements of the perfect social life in the community where the perfect polity is to be reared. Then, upon these natural principles of the head and heart, a course of public education is to proceed, disciplining the members by custom and by reason to the perfection of the social character, in a manner analogous to the discipline of the private moral character.

We find the same fundamental agreement with the mo-

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[1] *Polit.* iv. cap. 12, v. cap. 1.
[2] *Ibid.* ii. cap, 9, vii. cap. 14.
[3] *Ibid.* iii. cap. 17.
[4] *Ibid.* iii. cap. 13, p. 355, Du Val.
[5] *Polit.* ii. cap. 3
[6] *Ibid.* vii. cap. 1, 12.
[7] *Ibid.* vii. cap. 13.

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ral system of the Ethics, in the method of education proposed by Aristotle for the citizens of his polity. The maturity of the intellectual powers is here also to be the end to which the system tends. The members of the community are to be trained so as to be capable of enjoying the leisure and repose of a peaceful state. This they are to regard as their ultimate proper sphere of happiness, whilst at the same time they are disciplined to the virtues of that active life by which alone the permanence of their tranquillity can be secured. It is obvious how this harmonizes with the doctrine of the Ethics, which sets forth the happiness of the theoretic life as the highest bliss of our nature, but not independently of the practical duties of common life. For thus Aristotle directs the course through which the young must pass,—to commence with the body, then to proceed to the disposition of the heart, and to end with the intellect; the inferior principles being disciplined in subordination to, and with reference to the higher. Even the sports of childhood were not neglected by him in this scale of education; and he would further provide for the best bodily constitution of the citizen, by regulating the period of marriages with a view to a healthy offspring, and the care of the mothers during pregnancy. Here, indeed, we are shocked at finding in such an author a sanction to infanticide and abortion. The law, he says, should forbid the nurturing of the maimed;[1] and where a check to population is required, abortion should be produced before the quickening of the infant, no law of morality, he thinks, forbidding it at this period.[2] These are striking instances of the infirmity of a philosophy which substitutes an intrinsic agency in nature, for the counsels of an active and intelligent Being working on nature; for, according to such a philosophy, every thing adverse to the perfection of nature is a stumbling block. On the hypothesis of a Providence, the good and the evil may be contemplated with equal assurance that "the best" will in the end prevail. In the former case human reason removes, suppresses, and destroys; in the other it moderates, counteracts, and overrules, doing nothing with rash violence, but gently conspiring with the appointed course of things, in opening a way for good out of the evil. In Aristotle, the immoralities here noticed are, moreover, at direct variance with the whole spirit of his moral philosophy.

Again, the same moral complexion characterizes both the public and private discipline of the philosopher. The honourable, *το καλον*, predominates over both. By this standard every institution, whether of bodily or mental exercise, was to be regulated. No illiberal arts, such as required manual rather than intellectual skill, were to be taught; nor even were the liberal sciences to be pursued excessively, or with exclusive devotion to any particular ones, or with mercenary views; the occupation of leisure being the end proposed by the system of education. What was useful or necessary was to be learned, but in subserviency to the honourable; and the honourable rather than the useful or necessary.[3] Hence the stress laid by Aristotle on the arts of painting and music. It was, in the result, a general cultivation of the mind by literature combined with moral discipline, and not the storing it with particular sciences, to which his system of education was directed. He saw that the tendency of particular studies was evidently to contract the mental powers to that particular range of vision to which they were confined; whereas he sought rather to impart a largeness and masculine strength to the understanding, commensurate with the varied demands of the world in which human life is cast. It was what we should express by the education of the accomplished gentleman,—of one who, exempt from the drudgery of life, and having his actions freely at his own disposal, might be qualified for the highest functions to which nature has destined man in forming him a moral and social being. For it should be observed, that Aristotle throughout supposes an entire immunity from all servile employments, both to the happy man and the happy citizen.[4] According to his view, a large proportion of mankind were physically incapable, either of the happiness of moral beings, or of that of social life. Persons so imperfectly constituted he conceived to be wholly dependent on others, and to be by nature *relative* beings or slaves, their proper nature being comprized in this relationship of dependence.[5] To this class, accordingly, he would commit all the labours of agriculture, of the mechanical arts, and of the market, as well as the menial offices; whilst others more gifted by nature enjoyed leisure for the proper duties of man, in the various relations of a moral and social being.[6]

The condition of slavery was thus, we perceive, rested by Aristotle on abstract philosophical grounds. He viewed it as an institution of nature; differing in this from other philosophers, and from the popular notion of his own countrymen, who either founded it on the right of conquest, or an assumed original difference between Greek and Barbarian. This was a far more liberal view of the subject than that which prevailed generally; since it implied, that no one had a right to retain another as his slave when the individual was not thus physically dependent on others. Every one had a right to be free, who was capable of enjoying freedom in the performance of the duties for which man in his perfection was constituted. This doctrine further imposed on the master a strict moral attention to his slave. The slave was thrown on him not only for support, but for direction in his duties.[7]

That religion should have formed no part of the actual business of education in his system, was further consistent with his Ethics. The moral *καλον* terminated in the perfect fulfilment of all those relations in which man was placed as a being of this world. It was heightened by the consideration, that gods might delight in looking down on such perfection, and that in its ultimate state it might resemble the excellence of divinity. But it did not strike its roots into religion: nor did the *καλον* of social life. The accomplished citizen might be taught to contemplate himself in the thoughtful activity of a philosophical leisure, as holding a dignified station among men, analogous to the divine principles which maintained the order of the universe;[8] but there was no connection taught between his social virtues and his religious system. The religious colouring was only the borrowed light of philosophy. All active religion was consigned to the instrumentality of a particular body of men—the priests. The obligatory force of religion was recognized; but being lodged in an external establishment, as its depository and proper sanctuary, reverence was sought for it by outward bonds of respect, by

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[1] *Polit.* vii. cap. 16, εστω νομος μηδεν πεπηρωμενον τρεφειν.

[2] *Ibid.* vii. 16, πριν αισθησιν εγγενεσθαι και ζωην, εμποιεισθαι δει την αμβλωσιν, κ. τ. λ.

[3] *Ibid.* vii. cap. 14.

[4] *Eth. Nic.* x. cap. 6, 7; *Polit.* iii. cap. 6, iv. 4.

[5] *Polit.* i. cap. 3, 6.

[6] *Ibid.* vii. cap. 9, 10.

[7] *Ibid.* i. cap. 13, νουθετητεον γαρ μαλλον τους δουλους η τους παιδας.

[8] *Polit.* vii. cap. 3, Σχολη γαρ αν ὁ θεος εχοι καλως, και πας ὁ κοσμος, οἷς ουκ εισιν εξωτερικαι πραξεις παρα τας οικειας τας αυτων. "Sic hominum ad duas res, ut ait Aristotles, ad intelligendum et agendum, esse natum, quasi mortalem Deum." (Cicero *De Fin.* ii. cap. 13.)

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the privileges of the order to whose care it was intrusted, and the splendour of public spectacles connected with it. Aristotle, accordingly, treats the subject merely as one of policy. He observes, that no one of the rank of a mechanic or peasant should be appointed a priest, since it was proper that the gods should be honoured by the citizens; and he points out the importance of the religious character to the absolute sovereign of a state, in order to the obedience of the subject.[1]

Aristotle's account of his theoretic polity leaves off abruptly at the end of the 8th book; and the treatise is thus, as now extant, an imperfect development of his peculiar views. But the theory of the perfect polity is only a part of the very valuable materials of the *Politics*. The work embraces a wide survey of the social nature of man. Throughout, indeed, it may be studied as elements of the philosophy of history. It lays open the principles of preservation and decay inherent in the different constitutions, and points out the common principles, on which the maintenance of civil order, under any form whatever, must essentially depend.

Nor has the science of political economy been altogether overlooked by Aristotle. Incidental remarks on points belonging to the inquiries of the economist occur in his Politics. The nature of money, and of the wealth to which the introduction of money has given rise, particularly attracted his attention. It may suffice to show how accurately he has philosophized on this subject, to observe, that he has traced the origin of money to its convenience as a medium of exchange; and hence deduced its value as consisting in its power of representing *demand*.[2]

On the whole, justly to appreciate the labours of Aristotle in political science, we should compare them with the elaborate and eloquent work of Plato on the same subject—the celebrated *Republic*. Aristotle evidently had this work before him in the composition of his own, and in several places has made express allusions to it. In fact, his two treatises of the *Nicomachean Ethics* and the *Politics*, are together a refutation of the erroneous doctrines in moral and political philosophy contained in Plato's political speculations. It is but a small portion of Plato's *Republic* which strictly belongs to politics; the bulk of it being devoted to moral and metaphysical discussions. Aristotle's more exact philosophy discriminates the subjects heterogeneously blended in that episodic work. Aristotle has taken all that is excellent in the treatises of Plato into his own treatises, but at the same time has shown his own originality of thought in the correction and enlargement, as well as the systematic arrangement, of the principles there diffusely delivered. He candidly acknowledges that every thing that Socrates says, has in it "a vastness, and an exquisiteness, and an originality, and a penetration;" but modestly asserts for himself a right of discussing the doctrines, on the ground that "excellence in all points might well be thought difficult."[3]

Plato's theory was metaphysical throughout. That oneness which he sought to establish in his perfect republic was an abstract unity, the realizing of which constituted in his view the best polity, as in his Ethics the realizing of the abstract one "idea" of good constituted the morality of actions. Thus his governors are philosophers, and his virtue is wisdom. A character, on the other hand, decidedly practical, pervades the moral and political disquisitions of Aristotle. They are immediately adapted to the actual need of man. They have not, on this very account, that peculiar charm which belongs to Plato's writings. The speculative perfection shadowed out by Plato imparts an imaginative air to his disputations, and interests the feelings, whilst we read, amidst the reluctance of our judgment. And thus his works tend to a practical effect, independently of, and in opposition to, their real speculative character. But Aristotle, throughout intent on the business of human life, forbears to seize the imagination with romantic pictures of excellence, either in man individually or in society. He points out such happiness as is attainable by man, in that condition of the world in which man has been placed; or at least to which human endeavours may reasonably be directed. His discussions on moral subjects are accurate observations, and powerful reasonings, applied to things as they are. But this character in them renders them of more general use than Plato's speculations. The man of genius and of sensibility would perhaps feel a stronger stimulant to moral and social energies from the study of the animated pages of the *Republic*; but the generality of mankind would undoubtedly be more assisted in the work required of them from the constitution of their nature, by the real principles of human conduct delivered in the unambitious philosophy of Aristotle's Ethics and Politics.

Conclusion.

Conclusion.

Design of Aristotle's Philosophy—Style of his Writings—His Obscurity—Method of Discussion—Originality.

From the review which we have taken of the extant writings of Aristotle, it would appear that the great object of the philosopher was to discipline the mind by a deep and extensive course of literature. The various inquiries embraced in those writings,—the unwearied research into subjects, the most repulsive from their abstruseness, or the most interesting from their connection with the feelings and actions of man,—the richness of illustration from the volumes of ancient genius and observation of mankind with which they abound,—are so many proofs of the noble object proposed in his philosophy. It may be fully concluded, that it was not the mere sophist of former days, or the disputant on any given question, that Aristotle aimed to accomplish; but the really wise man; by cultivating all the moral and intellectual powers of the soul; in order that the great moral of the whole—the good towards which the constitution of nature tends—might be realized in each individual man so instructed and disciplined. Agreeably to this view of his philosophy is the answer attributed to him, when, on being asked what advantage had accrued to him from philosophy, he replied, "To do without constraint what some do through the fear of the laws."[4]

Some of his works are said to have been written in the form of dialogue. These were probably exoteric; that form being peculiarly adapted to the purpose of explanation, and that fuller discussion, which we regard as the characteristic of the exoteric treatises, as contrasted with the conciseness and suggestive form of the esoteric or acroamatic. Among his works are also men-

[1] *Polit.* v. 11, vii. 9. In *Œconom.* i. 5 (probably the work of his disciple Theophrastus), slaves are spoken of as the class for whom especially sacrifices and festivities should be appointed.

[2] *Ibid.* i. 9; *Eth. Nic.* v. 5.

[3] *Ibid.* ii. 6. Το μιν ων περιττον εχουσι παντες οἱ του Σωκρατους λογοι, και το κομφον, και το καινοτομον, και το ζητητικον· καλως δε παντα ισως χαλιπον.

[4] Diog. Laert. *in Aristot.*

Conclusion.

tioned *Epistles* to Philip, to Alexander, Olympias, Hephæstion, Antipater, Mentor, Ariston, Themistagoras, Philoxenus; besides a collection entitled *Epistles of the Selymbrians.* We have already noticed a hymn in praise of the virtues of his friend Hermeias, which formed matter of accusation against him on the ground of impiety. This hymn has been preserved by Diogenes Laertius. It consists of twenty-three lyric verses, in the manner and with something of the spirit of Pindar; celebrating Hermeias among the heroes who had sacrificed their lives for the cause of virtue. His biographer has also preserved the four lines inscribed by him on the statue of Hermeias erected at Delphi. His poetical talent was further displayed in verses addressed to Democritus, and in the composition of an elegy; of both of which poems the first lines are given by Laertius. The titles of various other philosophical works occur also in the catalogue of his writings. So laborious and so diversified were the literary pursuits of this great philosopher. These were works, too, written, we must remember, not by a sequestered individual enjoying the privacy of a privileged leisure, like that of the priests of Egypt, but amidst the agitation and troubles of Grecian politics, and in the courts of princes. We may well, therefore, wonder at the abstractedness of mind, the single-hearted zeal of philosophy, which thus steadily pursued its course, creating its own leisure, and keeping the stillness of its own thoughts. Probably, indeed, such writings as those of Aristotle could hardly have been produced, except with a concurrence of the opposite circumstances observed in his case. They imply at once the man of the world and the retired student,—ample opportunities for the contemplation of human nature in all the various relations of life, —familiarity with the thoughts of others by reading and conversation,—as well as intense private meditation—that communing with a man's own heart, which alone can extort the deep secrets of moral and metaphysical truth.

The style of his writings bears the impress of his devotion to the real business of philosophy. The excellence of his style is, we believe, the last thing to attract the notice of his readers; and yet, as a specimen of pure Greek, it is found, when examined, to stand almost unrivalled. The words are all selected from the common idiom of the language, but they are employed with the utmost propriety; and by their collocation are made further subservient to the perspicuity and force of his meaning. There is nothing superfluous, nothing intrusive, in his expressions; but the very ornaments add to the terseness of the style. The metaphors and illustrations employed are apt and striking analogies, availing as arguments, whilst by their simplicity they familiarize the truth conveyed to the mind. That these excellencies should escape the notice of the reader whilst he is engaged in the matter itself of the author, is a proof of the strict adaptation of the style to the matter. We can imagine, that to the Greek reader nothing could have been easier than to comprize the meaning of the philosopher. To the modern reader, of course, the necessity of studying the language gives an apparent hardness to expressions, whose propriety depends on an accurate perception of the genius of the language. Thus, what was a facility to the ancient reader, is a difficulty to the modern, until the modern, by study of the language, has brought himself as much as possible into the situation of the ancient. This observation will be illustrated by a comparison of the style of Plato with that of Aristotle. Plato's style, undulating with copiousness of diction, is more attractive to the modern reader; his meaning is more readily apprehended at the first glance, by the number of expressions which he crowds on a point, and their accumulated force of explanation. But in Aristotle, if we miss the force of a term or a particle,[1] or overlook the collocation of the words, we shall often entirely pervert his meaning.

There are, however, passages in which Aristotle departs from his usual conciseness, and approaches towards the eloquence of Plato. The concluding chapters of his *Nicomachean Ethics* may here be particularly pointed out; or a part of his ninth book of that treatise, in which, evidently imitating Plato, he compares the tumult of uncontrolled passions to the disturbance of civil sedition. There is a dignity and a pathos in these passages, controlled by the general character of severe precision belonging to his style, and admirably harmonizing with it.

Sometimes, indeed, his style is chargeable with too strict a conciseness, as well as, on the other hand, with too great prolixity. Both these opposite faults are in him the same in principle; resulting from extreme accuracy,—an excess in writing, which he has himself compared to that illiberality remarked in too close an attention to trifles in contracts.[2]

Nor is it meant to be denied that there is a considerable obscurity in the writings of Aristotle: but it is important to distinguish this obscurity from that of mere style. It is an effect of the peculiar design with which he appears to have composed his philosophical works. They are evidently for the most part outlines for the direction of the philosopher himself and his disciples in their disputations —notices of points of inquiry rather than full discussions of them. This is particularly observable in the treatises of the *Metaphysics*, the *Nicomachean Ethics*, and the *Rhetoric.* Sometimes he contents himself with a reference to his exoteric discussions.[3] It is probable that the most important works of his philosophy were not published in his lifetime, and that they thus constantly remained by him to receive successive improvements which his further observation had suggested. This may account for the abruptness in those treatises. In our progress through them, we come to discussions, which we had not been led to expect by any thing previous in the work. The seventh book of the *Ethics*, for instance, appears to have been an after-thought; and so also the eighth and ninth of the same treatise. The work might have been regarded as complete in itself without them. In the *Metaphysics*, indeed, we can hardly judge what was the exact plan of the author in the arrangement of the work, since it has descended to us in an imperfect, irregular form. But there are the same marks in it of successive additions from the author.[4] The writings of Aristotle having been left to Theophrastus, and not to his own relatives,—this would further imply that they were intended, chiefly and primarily, for those who had been trained in his school, and by whom his philosophy would be rightly transmitted.

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[1] It is surprising that Brucker (*Hist. Cr. Phil.* vol. i. p. 803) could speak of Aristotle's use of the particles as "singular," and the construction of his sentences as unusual. The perfect idiom of the language seems, on the contrary, strictly and beautifully observed by Aristotle.

[2] *Metaph.* ii. 3.

[3] *Eth. Nic.* i. c. ult., λεγεται δε περι αυτης και εν τοις εξωτερικοις λογοις αρκουντως ενια, και χρηστεον αυτοις. *Ibid.* vi. 4, πιστευομεν δε και περι αυτων και τοις εξωτερικοις λογοις. *De Cœlo*, i. 9, καθαπερ εν τοις εγκυκλιοις φιλοσοφημασι. *Eudem.* i. 8.

[4] Niebuhr (*History of Rome*, trans. p. 16) remarks this particularly of the *Rhetoric.*

The immediate occasion of this reserved mode of writing, may have been the jealousy of rival philosophers,[1] or the dread of pagan intolerance.

His method of discussion is conformable with the principles proposed in his Dialectic. It is throughout a sifting of the opinions and questions belonging to the subject of inquiry, by examining each in its several points of view, and showing the consequences involved in it. Accordingly, generally before he states his own immediate doctrine, he considers what may be urged on both sides of the question, stating the objections strongly and fairly, and giving the most candid construction to the views of his predecessors.[2] The difficulties proposed he sometimes briefly removes in passing on, having just glanced at them; at other times he devotes several sentences to their explanation. This, which is his method in parts of his system, is only a specimen of what is the collective result of the whole. His philosophy, dialectically viewed, is an analysis of the theories proposed by the philosophers who had preceded him. It is consistently with this, that he commences sometimes with observations on logical grounds,[3] or those views of a thing implied in the classifications of language; and afterwards inquires into the subject physically or philosophically; when the discussion proceeds on some acknowledged principles of physics or philosophy in general.

With respect to the originality of his writings, there can be no doubt that he derived important aid from the labours of his predecessors, and especially from those of Plato. An accurate examination of his writings will convince the reader, that they are the productions of one who had deeply drunk of the fountain of Plato's inspiration. But they show at the same time such a disciple as we may suppose the spirit of Plato would have delighted in; one who cherished the authority of the preceptor, and yet had the courage to love the truth still more;[4] one who thought it necessary to consult what others had said wisely and truly before him, and yet would examine a question finally with an unbiassed discriminative judgment.[5] Estimating his philosophy thus, we may pronounce it to be truly his own; it was the fruit of his own sagacious, penetrating mind. It is sufficient only to mention his disagreement with Plato on the doctrines of the ideas,—the origin of the universe,—and the immortality of the soul. He has been charged, indeed, with invidious opposition to Plato, with corruption and misrepresentation of the tenets of his predecessors in philosophy. Jewish writers have even absurdly accused him of plagiarism from the books of Solomon.[6] But there is no real foundation for these charges; they are at best but surmises; and they are fully contradicted by the internal evidence of the writings themselves.

(I. I.)

ARISTOXENUS, one of the most ancient musical writers, was born at Tarentum, a city in *Magna Græcia*, now Calabria. He was the son of a musician, and it appears that he lived about the time of Alexander the Great and his successors. His *Harmonics* in three books, all that are come down to us, together with Ptolemy's *Harmonics*, were first published by Gogavinus, but not very correctly, at Venice, in 1562, in 4to, with a Latin version. John Meursius next translated the three books of Aristoxenus into Latin, from the manuscript of Jos. Scaliger; but, according to Meibomius, very negligently. With these he printed at Leyden, in 1616, in 4to, Nicomachus and Alypius, two other Greek writers on music. After this Meibomius collected these musical writers together; to which he added Euclid, Bacchius senior, Aristides, and Quintilianus; and published the whole under the title of *Antiquæ Musicæ Auctores*, with a Latin version and notes, at Amsterdam, in 1652, in 4to. The learned editor dedicates these ancient musical treatises to Christina, queen of Sweden. Aristoxenus is said by Suidas to have written 452 different works, among which those on music were the most esteemed. His writings on other subjects are very frequently quoted by ancient authors, notwithstanding Cicero and some others say that he was a bad philosopher, and had nothing in his head but music. The titles of several of the lost works of Aristoxenus, quoted by Athenæus and others, have been collected by Meursius in his notes upon this author.

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[1] Valerius Maximus, viii. 14, reprehends Aristotle's sensitiveness on this point, mentioning his annoyance at the authorship of his *Rhetoric* being imputed to Theodectes, to whom he had presented the work for publication, and his care to assert his right to the treatise in a subsequent work.

[2] *Metaph.* iii. 1; *Topic.* i. 2; *Cœlo*, ii. 13, &c.

[3] *Ibid.* vii. 4; *Polit.* vii. 5. Occasionally he illustrates from etymology, as in deducing ηθος from εθος (*Eth. Nic.* ii. 1), σωφροσυνη from σωζειν φρονησιν (*Eth. Nic.* vi. 5). "It is a practice with us all," he observes (*Cœlo*, ii. 13, p. 467), "to pursue an inquiry, not as it belongs to the thing, but relatively to an opponent in argument."

[4] *Eth. Nic.* i. 6, αμφοιν γαρ οντοιν φιλοιν, οσιον προτιμαν την αληθειαν. This is also the sentiment of Plato, *Rep.* x. αλλ' ου προ γε της αληθειας τιμητεος ανηρ.

[5] *De Cœlo*, i. 10, το γαρ ειρηνην καταδικαζεσθαι δοκειν, κ. τ. λ.; *Polit.* ii. 6; *Metaph.* xiv. 8, p. 1002, Du Val.

[6] Brucker, *Hist. Crit. Phil.* vol. i. p. 794. This was merely to excuse their own adoption of the Aristotelian philosophy, as Brucker observes.

ARITHMETIC

History. IS a science which explains the properties of numbers, and shows the method or art of computing by them.

I.—HISTORY OF ARITHMETIC.

The various attempts of men in every state of society at representing numbers all spring from the same feeling, so strongly implanted in their breasts, which unceasingly prompts them to seek the applause of their fellows. It is the love of distinction that elevates the human character, infuses life and action through the mass, and impels it to undertake and achieve mighty projects. The daring and restless spirit of improvement often produces much transient misery by its failures; yet amidst all the vicissitudes which chequer and darken the tide of human affairs, it opens cheering prospects of the permanent amelioration of our species. The aspiring leader of a successful band, or the petty legislator of a rising community, is anxious to preserve the memory of the exploits he performed, or the benefits he conferred. But he is not content with obtaining the applause of his contemporaries: this fleeting existence is insufficient to fill his imagination: he looks anxiously beyond the grave, and sighs for the admiration of generations yet unborn. Hence the anxiety among all people to erect monuments of high achievements or illustrious characters. In the early periods of society a vast mound of earth, or a huge block of stone, was the only memorial of any great event; but after the simpler arts came to be known, efforts were made to transmit to posterity the representations of the objects themselves. Sculptures of the humblest kind occur on monumental stones in all parts of the world, sufficient to convey tolerably distinct images of the usual occupation and employments of the personages so commemorated. The next step in the progress of society was to reduce and abridge those rude sculptures, and thence form combinations of figures approaching to the hieroglyphical characters. At this epoch of improvement the first attempts to represent numerals would be made. Instead of repeating the same objects, it was an obvious contrivance to annex to the mere individual the simpler marks of such repetition. Those marks would of necessity be suited to the nature of the materials on which they were inscribed, and the quality of the instruments employed to trace them. In the historical representations, for instance, which the Mexicans and certain Tartar hordes painted on skins, a small coloured circle, as exhibiting the original counter, shell, or pebble, was repeated to denote numbers. But on the Egyptian obelisks the lower numbers, at least, are expressed by combined strokes. Curve lines were not admitted in the earliest rudiments of writing. Even after the use of hieroglyphics had been laid aside, and the artificial system of alphabetic characters adopted, the rectilineal forms were still preferred, as evidently appears in the Greek and Roman capitals, which, being originally of the lapidary sort, are much older than the small or current letters. One of the most ancient sets of characters, the Runic, in which the northern languages were engraved, combines almost exclusively simple strokes at different angles.

The primary numeral traces may, therefore, be regarded as the commencement of a philosophical and universal character, drawn from nature itself, and alike intelligible to all ages and nations. They are still preserved, with very little change, in the Roman notation. Those forms, prior to the adoption of the alphabet itself, were no doubt imported by the Grecian colonies that settled in Italy, and gave rise to the Latin name and commonwealth. Assuming a perpendicular stroke I to signify *one*, another such II would express *two*, the junction of a third III *three*, and so repeatedly till the reckoner had reached *ten*. See Plate LXXVI. The first class was now completed, and to intimate this the carver threw a dash across the stroke or common unit; that is, he employed two decussating strokes X to denote *ten*. He next repeated this mark to express *twenty*, *thirty*, and so forth, till he finished the second class of numbers. Arrived at *an hundred*, he would signify it by joining another dash to the mark for ten, or by merely connecting three strokes thus C. Again, the same spirit of invention might lead him to repeat this character in denoting *two hundred*, *three hundred*, and so forth, till the *third* class was completed. *A thousand*, which begins the fourth class on the *Denary Scale*, was therefore expressed by four combined strokes M, and this was the utmost length to which the Romans first proceeded by direct notation.

But the division of these marks afterwards furnished characters for the intermediate numbers, and hence greatly shortened the repetition of the lower ones. Thus, having parted in the middle the two decussating strokes X denoting *ten*, either the under half Λ, or the upper half V, was employed to signify *five*. Next, the mark C for an hundred, consisting of a triple stroke, was largely divided into Γ and L, either of which represented *fifty*. Again, the four combined strokes M, which originally formed the character for *a thousand*, came afterwards, in the progress of the arts, to assume a rounded shape ↀ, frequently expressed thus CIↃ, by two disparted semicircles divided by a diameter. This last form, by abbreviation on either side, gave two portions cI and IↃ to represent *five hundred*.

It was an easy process, therefore, to devise a universal character for expressing numbers. But the task was very different to reduce the exhibition of language in general to such concise philosophical principles. This attempt seems accordingly to have been early abandoned by all nations except the Chinese. The inestimable advantage of uniting again the whole human race, in spite of the diversity of tongues, by the same permanent system of communication, was sacrificed for the easier attainment of representing by artificial signs those elementary and fugitive sounds into which the words of each particular dialect could be resolved. Hence the ALPHABET was invented, which had very nearly attained its present form at the period when the Roman commonwealth was extending its usurpation over Italy. About that epoch a sort of reaction seems to have arisen between the artificial and the natural systems; and the numeral strokes were finally displaced by such alphabetic characters as then most resembled them. (See Plate LXXVI.) The ancient Romans employed the letter I to represent the single stroke or mark for *one*; they selected the letter V, since it resembles the upper half of the two decussating strokes or symbol, for *five*; the letter X exactly depicted the double mark for *ten*; again, the letter L was adopted as resem-

History. bling the divided symbol for *fifty;* while the entire symbol, or the tripled stroke, denoting *an hundred*, was exhibited by the hollow square ⊏, the original form of the letter C before it became rounded over. The quadrupled stroke for a *thousand* was distinctly represented by the letter M, and its variety by the compound character cIↃ, consisting of the letter I inclosed on both sides by C, and by the same letter reversed; a portion of this, again, or IↃ, being condensed into the letter D, expressed *five hundred.* The letters C and M, beginning the words *Centum* and *Mille*, might have a farther claim to represent an *hundred* and *a thousand;* but the coincidence was merely accidental, since these terms migrated probably from the Greek words ἑκατον and χιλια.

This was the limit of numeration among the early Romans; but, in the progress of refinement, they repeated the symbols of a thousand to denote the higher terms of the Denary Scale. Thus, ccIↃↃ was employed to represent *ten thousand*, and cccIↃↃↃ to signify *an hundred thousand*, the letter I, inclosed between the c Ↄ, being, for the sake of greater distinctness, elongated. Again, each of these being divided, gives IↃↃ for *five thousand*, and IↃↃↃ for *fifty thousand.* These characters, however, were often modified and abbreviated in monumental inscriptions. By drawing a horizontal line over the letters, their value was augmented *one thousand times.* In the plate so often referred to, we have endeavoured, from the best authorities, to exhibit, under the title of *Lapidary Numerals*, a complete specimen of the various contractions used by stone-cutters among the Romans. It was customary with them, for the sake of abbreviation, to reckon, as rude tribes are apt to do, partly backwards. Thus, instead of *octodecem* and *novemdecem*, the words for *eighteen* and *nineteen*, they frequently used *duodeviginti* and *undeviginti*, as more elegant and expressive. This practice led to the application of *deficient* numbers, an improvement scarcely to be expected from a people so little noted for invention. Instead of writing *nine* thus, VIIII, by joining *four* to *five*, they counted *one* back from *ten*, or placed I before X. In the same way they represented *forty*, and *four hundred*, *ninety*, and *nine hundred*, by XL, and CD, XC, and CM.

Such, we have no doubt, is the real account of the rise and progress of the Roman numerals. It perfectly agrees with the few hints left us by Aulus Gellius, who expressly says that I and X were anciently represented by one and two strokes; though philologers, misled by partial glimpses, have indeed given a very different statement. Priscian the grammarian, who flourished in the reign of the emperor Justinian, asserts that the mark I was only borrowed from the Athenians, being adopted by them as the principal letter of the word MIA, or *one*, the M of which is considered as mute; that V or U was employed by the Romans to denote *five*, because it is the fifth vowel in the common order; that X was assumed to represent *ten*, as being the tenth consonant, and likewise following the V; that L was taken to signify *fifty*, being sometimes interchanged with N, which, as a small letter, expressed that number among the Greeks; that C was adopted to mark *an hundred*, because it is the first letter of the word *centum;* that D, being the next letter of the alphabet, was employed to signify *five hundred;* and that M was borrowed from the Greek letter X for XIAIA, or *a thousand*, only that it was rounded at the ends to distinguish it from the symbol for ten.

After the system of Roman numerals, however, had acquired its full extent, the solicitude of superstition long preserved some traces of the rudest and most primitive mode of chronicling events. At the close of each revolving year, generally on the ides of September, the Prætor Maximus was accustomed, with great ceremony, to drive a *nail* in the door on the right side of the temple of Jupiter, next that of Minerva, the patron of learning and the inventor of numbers. On such occasions they elected a dictator for the sole purpose of driving the sacred nail, and beginning a more propitious year. Hence the expression of Cicero—*Ex hoc die, clavum anni movebis.*

Chinese numerals. As the Chinese constructed the Swan-pan on the principles of the Roman Abacus (See ABACUS), so they likewise, at the remotest epoch of the empire, framed a system of numerals in many respects similar to those which the Romans probably derived from their Pelasgic ancestors. This will appear from the inspection of the characters engraved on Plate LXXVI. It is only to be observed that the Chinese mode of writing is the reverse of ours; and that, beginning at the top of the leaf, they descend in parallel columns to the bottom, proceeding, however, from right to left, as practised by most of the Oriental nations.

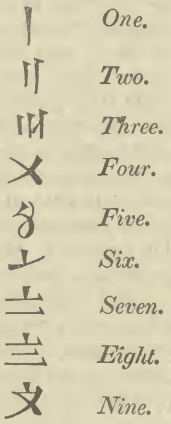
Instead of the vertical lines used by the Romans, we therefore meet with horizontal ones in the Chinese notation. Thus, *one* is represented by a horizontal stroke, with a sort of barbed termination; *two* by a pair of such strokes; and *three* by as many parallel strokes; the mark for *four* has four strokes, with a sort of flourish; three horizontal strokes, with two vertical ones, form the mark for *five;* and the other symbols exhibit the successive strokes abbreviated, as far as *nine.* *Ten* is figured by a horizontal stroke, crossed with a vertical score, to show that the first rank of the Denary Scale was completed; *an hundred* is signified by two vertical scores, connected by three short horizontal lines; *a thousand* is represented by a sort of double cross; and the other ranks, ascending to *an hundred millions*, have the same marks successively compounded. In addition to the figures in the Plate, we shall here give *fac similes* of a complete set of numerals, printed with metallic types in 1814, at Serampore, in the Elements of Chinese Grammar, by the Reverend Dr Marshman. In these characters, it will be perceived that each symbol has, for the sake of distinction, a small zero or ° annexed to it.

One,	一°	*Yih.*	*Ten,*	十°	*Shih.*
Two,	二°	*Irr.*	*A Hundred,*	百°	*Pŭh.*
Three,	三°	*San.*	*A Thousand,*	千°	*Ts'hyen.*
Four,	四°	*Sè.*	*Ten Thousand,*	萬°	*Wàn.*
Five,	五°	*Ngóo.*	*A hundred Thousand,*	億°	*Eè.*
Six,	六°	*Lyeù.*	*A Million,*	兆°	*Chaò.*
Seven,	七°	*Ts'hĭh*	*Ten Millions,*	京°	*King.*
Eight,	八°	*Păh.*	*A hundred Millions,*	垓°	*Kyai.*
Nine,	九°	*Kyéu.*			

The numbers *eleven, twelve*, &c. are represented by putting the several marks for *one, two*, &c. the excesses above *ten*, immediately below its symbol. But to denote *twenty, thirty*, &c. the marks of the multiples *two, three*, &c. are placed above the symbol for *ten.* This distinction is pursued through all the other cases. Thus, the marks for *two, three*, &c. placed over the symbols of *an hundred* or of

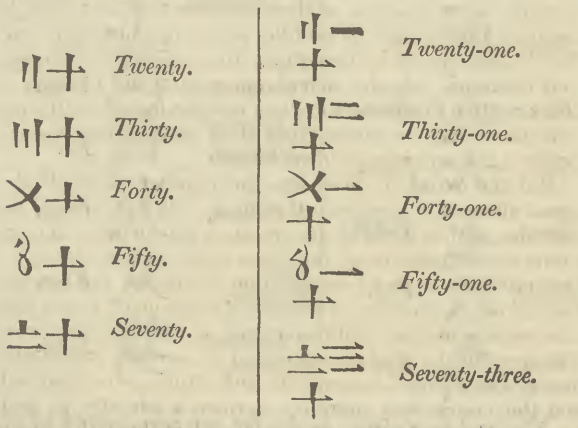
History. *a thousand*, signify so many *hundreds* or *thousands*. The character for *ten thousand*, called *wàn*, appears to have been the highest known at an early period of the Chinese history; since, in the popular language at present, it is equivalent to *all*. But the Greeks themselves had not advanced farther. In China, *wàn wàn* signifies *ten thousand times ten thousand*, or *an hundred millions;* though there is also a distinct character for this high number. In the eastern strain of hyperbole, the phrase *wàn wàn* far outdoing *a thousand years*, the measure of Spanish loyalty, is the usual shout of long live the emperor! The Chinese character *chaò* for *a million*, though not of the greatest antiquity, is yet as old as the time of Confucius. The characters for *ten* and for *an hundred millions* are not found in their oldest books, but occur in the imperial dictionary.

Such is the very complete but intricate system of Chinese numerals. It has been constantly used, from the remotest times, in all the historical, moral, and philosophical compositions of that singular people. The ordinary symbols for words, or rather things, are, in their writings, generally blended with skill among those characters. But the Chinese merchants and traders have transformed this system of notation into another, which is more concise, and better adapted for the details of business. The changes made on the elementary characters, it will be seen, are not very material. The *one*, *two*, and *three*, are represented by perpendicular strokes; the symbols for *four* and *five* are altered; *six* is denoted by a short score above an horizontal stroke, as if to signify that *five*, the half of the index of the scale, had been counted over; *seven* and *eight* are expressed by the addition of one and two horizontal lines; and the mark for *nine* is composed of that for *six*, or perhaps at first a variety of *five*, joined to that of *four*.

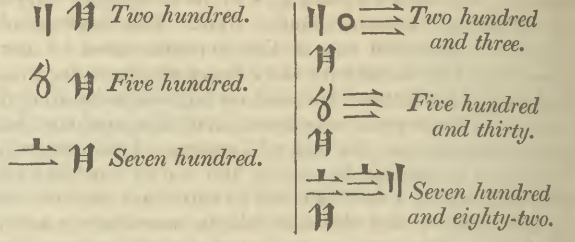


To represent *eleven*, *twelve*, &c. in this mode, a single stroke is placed on the left of the cross for ten, and the several additions of *one*, *two*, &c. annexed on the right.

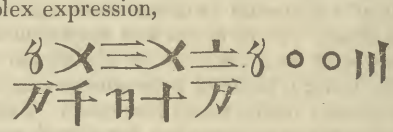
From *twenty* to *an hundred*, the signs of the multiples are prefixed to the mark for *ten*.



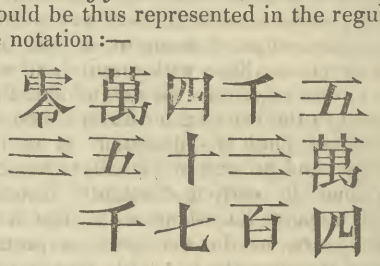
The same method is pursued through the hundreds, the marks of the several multiples being always placed on the left hand before the contracted symbol of *pŭh*, or *an hundred*. The additions are made on the right, with a small cipher or circle (o), called *ling*, when necessary, to separate the place of units. The distinction between *two hundred and three* and *five hundred and thirty* deserves to be particularly remarked.



A similar process extends to the notation of thousands, but for ten thousand the character *wàn* is abbreviated. As a specimen of their combination, we select the following complex expression,



which denotes *five hundred and forty-three millions, four hundred and seventy-five thousand, and three.* The same number would be thus represented in the regular system of Chinese notation:—



Here the first column on the right hand presents the marks for *fifty* and *four*, with the interjacent character *wàn*, or *ten thousand;* the next column to the left has the several marks for *a thousand*, *three*, and *an hundred;* the middle column exhibits the symbols of *forty* and of *seven;* the adjacent column repeats the character *wàn*, or *ten thousand*, and then presents those for *five* and *a thousand;* and the last column has the symbol *ling*, or the *rest*, which fills up the blank, with the mark for *three*.

The last expression seems abundantly complicated, and yet it is unquestionably simpler and clearer than the corresponding notation with Roman numerals, as represented below.

IOOOOOOO · OOOOOIOOOOO ·
OOOOOIOOOOO · OOOOOIOOOOO ·
OOOOOIOOOOO · OOOOIOOOO ·
OOOOIOOO · OOOOIOOOO · OOOIOOO ·
OOOIOOO · OOOIOOO · OOOIOOO ·
IOOO · OOIOO · OOIOO · IOO · III.

From such an intricate example, the imperfection of the Roman system will appear the more striking.

The abbreviated process of the Chinese traders was probably suggested by the communication with India, where the admirable system of denary notation has, from the earliest ages, been understood and practised. The adoption of a small cipher to fill the void spaces was a most material improvement on the very complex character *ling*, used formerly for the same purpose.

About the close of the 17th century, the Jesuit missionaries Bouvet, Gerbillon, and others, then residing at the court of Pekin, and able mathematicians, appear to

History. have still farther improved the numeral symbols of the Chinese traders, and reduced the whole system to a degree of simplicity and elegance of form scarcely inferior to that of our modern ciphers. With these abbreviated characters they printed, at the imperial press, Vlacq's *Tables of Logarithms*, extending to ten places of decimals, in a beautiful volume, of which a copy was presented by Father Gaubil, on his return to Europe, about the year 1750, to the Royal Society of London. From this very curious work, the marks in Plate LXXVI. entitled Improved Chinese Numerals, were carefully copied. No more than nine characters, it will be seen, are wanted; the upright cross + for *ten* being a mere redundancy. The marks for *one*, *two*, and *three*, consist of parallel strokes as before; an oblique cross × denotes *four;* and a sort of bisected ten signifies *five*. This symbol again, being contracted into the angular mark ∠, and combined with *one*, *two*, or *three* strokes drawn below it, represents *six*, *seven*, or *eight;* and still more abridged and annexed to the sign of four, it denotes *nine*. The distinction of units, tens, hundreds, &c. is indicated by giving the strokes alternately an horizontal and vertical position, while the blanks or vacant bars are expressed by placing small zeros. The very important collection of logarithmic tables just mentioned was printed by the command of the emperor Kang-hi, a man of enlarged views, who governed China with dignity and wisdom during a long course of years. This enlightened prince was much devoted to the learning of Europe, and is reported to have been so fond of calculation as to have those tables abridged and printed in a smaller character, which precious volume he carried constantly fastened to his girdle. The emperor Kien-long, who, after a beneficent reign of 60 years, in the decline of a protracted life spontaneously resigned the imperial office to his son, discovered a similar taste for the mathematical sciences.

Greek numerals. The Greeks, after having communicated to the founders of Rome the elements of the numeral characters which are still preserved, again exercised their inventive genius in framing new systems of notation. Discarding the simple original strokes, they sought to draw materials of construction from their extended alphabet. They had no fewer than three different modes of proceeding. 1*st*, The letters of the alphabet, in their natural succession, were employed to signify the smaller ordinal numbers. In this way, for instance, the books of Homer's *Iliad* and *Odyssey* are usually marked. But the practice could scarcely be older than the time of Aristotle, who, it is well known, first collected and arranged those immortal poems, in the edition of the *Casket*, for the use of his illustrious pupil Alexander the Great. 2*d*, The first letters of the words for numerals were adopted as abbreviated symbols. Thus, employing capitals only, I, being retained as before, to denote *one*, the letter Π of ΠΕΝΤΕ' marked *five*, the Δ of ΔΕΚΑ denoted *ten*, the H of 'ΕΚΑΤΟΝ, anciently written ΗΕΚΑΤΟΝ, expressed *an hundred*, the X of ΧΙΛΙΑ *a thousand*, and the letter M of the word ΜΥΡΙΑ represented *ten thousand*. A simple and ingenious device was used for augmenting the powers of those symbols; a large Π placed over any letter made it signify *five thousand* times more. Thus, |$\overline{\Delta}$| denoted *fifty thousand*, and |$\overline{H}$| *five hundred thousand*. See Plate LXXVI. 3*d*, But a mighty stride was afterwards made in numerical notation by the Greeks, when they distributed the twenty-four letters of their alphabet into three classes, corresponding to *units*, *tens*, and *hundreds*. To complete the symbols for the nine digits, an additional character was introduced in each class. The mark ϛ, called *episêmon*, was inserted among the units, immediately after ι, the letter denoting five; and the *koppa* and *sanpi*, represented by ϟ, ϡ, or ϡ terminated respectively the range of *tens* and of *hundreds*, or expressed ninety and nine hundred. This arrangement of the symbols, it is obvious, could extend only to the expression of nine hundred and ninety-nine; but, by subscribing an *iota* under any character, the value was augmented a thousand fold, or by writing the letter M, or the mark for a *myriad*, or ten thousand, under it, the effect was increased ten times more. This last modification was sometimes more simply accomplished by placing two dots over the character.

Such is the beautiful system of Greek numerals, so vastly superior in clearness and simplicity to the Roman combination of strokes. It was even tolerably fitted as an instrument of calculation. Hence the Greeks early laid aside the use of the *abacus;* while the Romans, who never showed any taste for science, were confined, by the total inaptitude of their numerical symbols, to the practice of the same laborious manipulation.

It should, however, be remarked, that the Greeks distinguished the theory from the practice of arithmetic, by separate names. The term *Arithmetic* itself was restricted by them to the science which treats of the nature and general properties of numbers; while the appellation *Logistic* was appropriated to the collection of rules framed to direct and facilitate the common operations of calculation. The ancient systems of arithmetic, accordingly, from the books of Euclid to the treatise of Böethius and the verses or commentaries of Capella, are merely speculative, and often abound with fanciful analogies. Pythagoras had brought from the East a passion for the mystical properties of numbers, under the veil of which he probably concealed some of his secret or esoteric doctrines. He regarded *Numbers* as of divine origin, the fountain of existence, and the model and archetype of all things. He divided them into a variety of different classes, to each of which were assigned distinct properties. They were prime or composite, perfect or imperfect, redundant or deficient, plane or solid; they were triangular, square, cubic, or pyramidal. *Even* numbers were held by that visionary philosopher as feminine, and allied to earth; but the *odd* numbers were considered by him as endued with masculine virtue, and partaking of the celestial nature. He esteemed the *unit*, or *monad*, as the most eminently sacred, and as the parent of all scientific numbers; he viewed *two*, or the *duad*, as the associate of the *monad*, and the mother of the elements; and he regarded *three*, or the *triad*, as perfect, being the first of the masculine numbers, comprehending the beginning, middle, and end, and hence fitted to regulate by its combinations the repetition of prayers and libations. As the *monad* represented the Divinity, or the Creative Power, so the *duad* was the image of Matter; and the *triad*, resulting from their mutual conjunction, became the emblem of Ideal Forms.

Mystical properties of numbers.

But the *tetrad*, or *four*, was the number which Pythagoras affected to venerate the most. It is a square, and contains within itself all the musical proportions, and exhibits by summation all the digits as far as ten, the root of the universal scale of numeration; it marks the seasons, the elements, and the successive ages of man; and it likewise represents the cardinal virtues, and the opposite vices. The ancient division of mathematical science into Arithmetic, Geometry, Astronomy, and Music, was fourfold, and the course was therefore termed a *tetractys* or *quaternion*. Hence, Dr Barrow would explain the oath familiar to the disciples of Pythagoras, "I swear by him who communicated the *Tetractys*."

Five, or the *pentad*, being composed of the first male and female numbers, was styled the number of the world. Repeated anyhow by an odd multiple, it always re-appeared; and it marked the animal senses and the zones of the globe.

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Six, or the *hextad*, being composed of its several factors, was reckoned perfect and analogical. It was likewise valued as indicating the sides of the cube, and as entering into the composition of other important numbers.

Seven, or the *heptad*, formed from the junction of the *triad* with the *tetrad*, has been celebrated in every age. Being unproductive, it was dedicated to the virgin Minerva, though possessed of a masculine character. It marked the series of the lunar phases, the number of the planets, and seemed to modify and pervade all nature.

Eight, or the *octad*, being the first cube that occurred, was dedicated to Cybele, the mother of the gods, whose image in the remotest times was only a cubical block of stone.

Nine, or the *ennead*, was esteemed as the square of the *triad*. It denotes the number of the Muses, and, being the last of the series of digits, and terminating the tones of music, it was inscribed to Mars.

Ten, or the *decad*, from the important office which it performs in numeration, was, however, the most celebrated for its properties. Having completed the cycle and begun a new series of numbers, it was aptly styled *apocatastasic* or periodic, and therefore dedicated to the double-faced Janus.

The cube of the *triad*, or the number *twenty-seven*, expressing the time of the moon's periodic revolution, was supposed to signify the power of the lunar circle. The quaternion of celestial numbers, *one*, *three*, *five*, and *seven*, joined to that of the terrestrial numbers *two*, *four*, *six*, and *eight*, compose the number *thirty-six*, the square of the first perfect number *six*, and the symbol of the universe, distinguished by wonderful properties.

But it would be endless to recount all the visions of the Pythagorean school; nor should we descend to notice such fancies, if, by a perpetual descent, the dreams of ancient philosophers had not, in the actual state of society, still tinctured our language, and mingled with the various institutions of civil life. Not to wander in search of illustration, we see the predilection for the number *seven* strongly marked in the customary term of apprenticeships, in the period required for obtaining academical degrees, and in the legal age of majority.

Numerical fancies of the Chinese.

The Chinese appear, from the remotest epochs of their empire, to have entertained the same admiration of the mystical properties of numbers that Pythagoras imported from the East. Distinguishing numbers into even and odd, they considered the former as terrestrial, and partaking of the feminine principle *Yang*; while they regarded the latter as of celestial extraction, and endued with the masculine principle *Yn*. The even numbers were represented by small black circles, and the odd ones by similar white circles, variously disposed, and connected by straight lines. See Plate LXXVI. The sum of the five even numbers *two*, *four*, *six*, *eight*, and *ten*, being *thirty*, was called the number of the *Earth*; but the sum of the five odd numbers *one*, *three*, *five*, *seven*, and *nine*, or *twenty-five*, being the square of *five*, was styled the number of *Heaven*. The nine digits were likewise grouped in two different ways, termed the *Lo-chou* and the *Ho-tou*. The former expression signifies the *Book of the River Lo*, or what the great Yu saw delineated on the back of the mysterious tortoise which rose out of that river: it may be conceived from this arrangement.

Nine

Four *Two*

Three *Five* *Seven*

Eight *Six*

One

Nine was reckoned the head, and *one* the tail, of the tortoise; *three* and *seven* were considered as its left and right shoulders; and *four* and *two*, *eight* and *six*, were viewed as the fore and the hind feet. The number *five*, which represented the heart, was also the emblem of Heaven. We need scarcely observe, that this group of numbers is nothing but the common *magic-square*, each row of which makes up *fifteen*.

As the *Lo-chou* had the figure of a square, so the *Ho-tou* had that of a cross. It is what the emperor Fou-hi observed on the body of the horse-dragon which he saw spring out of the river Ho. The central number was *ten*, which, it is remarked by the commentators, terminates all the operations on numbers.

Seven
Two
Five *Three* *Ten* *Four* *Nine*
Five
One
Six

The Greek system of notation proceeded directly as far as *ten thousand*, comprising four terms of the *Denary Scale*; but by subscribing M, the initial letter of μυρια, it was carried over another similar period to signify *hundreds of millions*. But the penetrating genius of Archimedes quickly discerned the powers and unfolded the properties of such progressions. In a curious tract, entitled Ψαμμιτης or *Arenarius*, this philosopher amused himself with showing that it was possible, assuming the estimation of Aristarchus of Samos, and other astronomers of that age, to represent the number of particles of sand which would be required to fill the sphere of the universe. He took the limit of the ordinary numeral system, or *ten thousand times ten thousand*, that is, *an hundred millions*, as the root of a new scale of progression, which therefore advanced eight times faster than the simple denary notation. Archimedes proposed to carry this comprehensive system as far as eight periods, which would therefore correspond to a number expressed in our mode by sixty-four digits. From the nature of a geometrical progression, he demonstrated that proportional numbers would range at equal distances, and consequently that the product of any two numbers must have its place determined by the sum of the separate ranks,—a principle which involves the theory of logarithms.

Extension of notation proposed by Archimedes.

The fine speculation of the Sicilian philosopher does not, however, appear to have been carried into effect; and without actually performing those calculations, he contents himself by pointing out the process, and stating the approximate results. But Apollonius, the most ingenious and inventive, next to Archimedes, of all the ancient mathematicians, resumed that scheme of numeration, simplified the construction of the scale, and reduced it to a commodious practice. For greater convenience, he preferred the simple myriad as the root of the system, which, therefore, proceeded by successive periods, corresponding to four of our digits. The periods were distinguished by breaks or blanks. That most important office which, in the modern system of notation, the cipher performs, by marking the rank of the digits, was indeed unknown to the earlier Greeks. They were hence obliged, when the lower periods failed, to repeat the letters Μυ. or the contraction for μυρια, *ten thousand*. Thus, to express *thirty-four trillions*, they wrote λδ Μυ. Μυ. Μυ. To signify *units* separately, it was customary with them to prefix the mark M°. or the abbreviation for *monad*.

and by Apollonius.

The procedure of the Greek arithmetician was necessarily slower and more timid than our simple yet refined mode of calculation. Each step in the multiplication of

History. complex numbers appeared separate and detached, without any concentration which the moderns obtain, by carrying forward the multiples of ten, and blending together the different members of the product. In ancient Greece, the operations of arithmetic, like writing, advanced from left to right; each part of the multiplier was in succession combined with every part of the multiplicand; and the several products were distinctly noted, or, for the sake of compactness, grouped and conveniently dispersed till afterwards collected into one general amount.

Pappus of Alexandria, in his valuable *Mathematical Collections*, has preserved a set of rules which Apollonius had formed, for facilitating arithmetical operations. These are, in the cautious spirit of the ancient geometry, branched out into no fewer than twenty-seven propositions, though all comprised in the principle formerly stated by Archimedes, That the product of two integers of different ranks will occupy a rank corresponding to the sum of the component orders. Suppose μ were to be multiplied into σ, or *forty* into *two hundred:* Take the lower corresponding characters δ and β, or *four* and *two*, which were called πυθμενες or radicals, the one depressed ten times, and the other an hundred times, and multiply their product η, or *eight*, successively by the ten and the hundred, or at once by a thousand, and the result is η or *eight thousand.*

Tirel mon of calculation. We shall take an example in multiplication, affording more variety than such as occur in Eutocius, which generally consist in the mere squaring of numbers. Let it be required to multiply *eight hundred* and *sixty-two* by *five hundred* and *twenty-three.* The operation would be performed in this way.

$$
\begin{array}{cccccccc}
 & & & & & \omega & \xi & \beta \\
 & & & & & \varphi & \varkappa & \gamma \\
\hline
 & \ddot{\mu} & \ddot{\gamma} & \underset{,}{\alpha} & & & & \\
 & & \ddot{\alpha} & \varsigma & & & & \\
 & & & \underset{,}{\alpha} & \sigma & \mu & & \\
 & & & \beta & \upsilon & & & \\
 & & & & \varrho & \pi & \varsigma & \\
\hline
 & \ddot{\mu} & \ddot{\varepsilon} & \omega & \varkappa & \varsigma & &
\end{array}
$$

In the first range, φ multiplied into ω, being the same as the product of *eight* and *five* augmented ten thousand times, is consequently denoted by $\ddot{\mu}$ or $\underset{M}{\mu}$; φ multiplied into ξ gives the same result as *five* times *six* increased a thousand fold, and therefore expressed by $\ddot{\gamma}$ or $\underset{M}{\gamma}$; and φ multiplied into β evidently makes a thousand, or $\underset{,}{\alpha}$. In the second range, $\varkappa$ multiplied into ω gives the same product as *eight* repeated *twice* and then augmented a thousand times, or denoted by $\ddot{\alpha}\varsigma$; $\varkappa$ multiplied into ξ is equivalent to *six* repeated *twice*, and afterwards increased an hundred fold or, expressed by $\underset{,}{\alpha}\sigma$; and $\varkappa$ multiplied by β gives forty, the value of μ. In the third range, γ multiplied into ω produces twenty-four hundred, which is denoted by $\beta\upsilon$; γ multiplied into ξ makes an hundred and eighty, or $\varrho\pi$; and, lastly, γ multiplied into β gives ς, the symbol for *six*. Collecting the scattered members into one sum, the result of the multiplication of *eight hundred and sixty-two* by *five hundred and twenty-three* is $\ddot{\mu}\ddot{\varepsilon}\omega\varkappa\varsigma$, or *four hundred and fifty thousand eight hundred and fifty-six.*

But the Greek notation was not adapted for the descending scale. To express fractions, two distinct methods were followed. 1. If the numerator happened to be unit, the denominator was indicated by an accent. Thus δ' signified *one fourth*, and $\varkappa\varepsilon'$ *one twenty-fifth;* but *one half* being of most frequent recurrence, was signified by a particular character, varying in its form, $\subset$, $\angle$, C', or κ. 2. In other cases it was the practice of the Greeks to write the denominator as we do an exponent, a little above the denominator, and towards the right hand. Thus, $\beta^{\iota\alpha}$ intimated *two-elevenths*, and $\pi\alpha^{\varrho\varkappa\alpha}$ *eighty-one*, of *an hundred and twenty-one* parts.

As an illustration of the management of fractions, we select an example somewhat complicated, from the commentary which Eutocius of Ascalon wrote about the third century of our era, on the *Tract of Archimedes* concerning the quadrature of the circle. Let it be required to multiply the mixed number *one thousand* and *thirty-eight* with *nine-elevenths*, by itself.

$$
\begin{array}{cccccccccc}
 & & & & & & \underset{,}{\alpha} & \omega & \lambda & \eta & \theta^{\iota\alpha} \\
 & & & & & & \underset{,}{\alpha} & \omega & \lambda & \eta & \theta^{\iota\alpha} \\
\hline
 & & & \varrho & \pi & \gamma & \underset{,}{\eta} & \underset{,}{\omega} & \varsigma & \eta & \beta^{\iota\alpha} \\
 & & & \underset{M}{\ } & \underset{M}{\ } & \underset{M}{\ } & & & & & \\
\pi & \xi\delta & \beta & \delta & \varsigma & \upsilon & \chi & \nu & \delta & & \varsigma^{\iota\alpha} \\
 & \underset{M}{\ } & \underset{M}{\ } & \underset{,}{\ } & \underset{,}{\ } & & & & & & \\
 & \gamma & \beta & \delta & \vartheta & \sigma & \mu & \varkappa & \delta & & \varsigma^{\iota\alpha} \\
 & \underset{M}{\ } & \underset{M}{\ } & \underset{,}{\ } & & & & & & & \\
 & \underset{,}{\eta} & \underset{,}{\varsigma} & \upsilon & \sigma & \mu & \xi & \delta & \varsigma & & \varsigma^{\iota\alpha} \\
 & & & & & & \omega & \iota & \eta & & \beta^{\iota\alpha} \\
 & & & & & & \chi & \nu & \delta & & \varsigma^{\iota\alpha} \\
 & & & & & & & \varkappa & \delta & & \varsigma^{\iota\alpha} \\
 & & & & & & & & \varsigma & & \varsigma^{\iota\alpha} \\
 & & & & & & & & & & \pi\alpha^{\varrho\varkappa\alpha} \\
\hline
 & \tau & \lambda & \eta & & \underset{,}{\alpha} & \sigma & \nu & \alpha & \zeta^{\iota\alpha} & \pi\alpha^{\varrho\varkappa\alpha} \\
 & & \underset{M}{\ } & & & & & & & & \\
\text{or,} & \tau & \lambda & \eta & & \underset{,}{\alpha} & \sigma & \nu & \beta & \lambda\zeta^{\iota\alpha\varkappa} & \\
 & & \underset{M}{\ } & & & & & & & &
\end{array}
$$

It is to be observed, that, to multiply the several integers by the fraction nine-elevenths, amounts to their multiplication by nine, and the subsequent division by eleven. The excesses being *two* and *six-elevenths*, are denoted by $\beta^{\iota\alpha}$ and $\varsigma^{\iota\alpha}$, while the product of the fraction itself gives *eighty-one* of *an hundred and twenty-one* parts, expressed by $\pi\alpha^{\varrho\varkappa\alpha}$.

But the laborious operations that such complex fractions required were afterwards superseded by the use of *sexagesimals*, which, we have already observed, the astronomers, and especially Ptolemy, had introduced. "The division of the circumference of the circle into three hundred and sixty equal parts or degrees was no doubt originally founded on the supposed length of the year, which, expressed in round numbers, consists of twelve months, each composed of thirty days. The radius approaching to the sixth part of the circumference would contain nearly sixty of those degrees; and after its ratio to the circumference was more accurately determined, the radius still continued to be distinguished into the same number of divisions, which likewise bore the same name. As calcu-

History. lation now aimed at greater accuracy, each of these sixty divisions of the radius was, following the uniform progression, again subdivided into sixty equal portions called minutes; and, repeating the process of sexagesimal subdivision, seconds and thirds were successively formed. The operations with sexagesimal fractions were performed in the descending scale, on a principle quite similar to that which Archimedes had before laid down. Each period of the multiplier, still proceeding from the left hand, was multiplied into a period of the multiplicand; and this product was then thrown to a rank depressed as much as the descents of both its factors. Thus, minutes multiplied into seconds produced thirds; and seconds multiplied into thirds produced fifths." *Edinburgh Review*, vol. xviii. p. 200.

As an exemplification of this process, we shall take the question proposed by Theon to find the square of the side of a regular decagon inscribed in a circle, or the chord of *thirty-six* degrees, which, according to Ptolemy's computation, measured, in sexagesimal parts of the radius, *thirty-seven* degrees, *four* minutes, and *fifty-five* seconds. The multiplication is thus effected:

λζ	δ	νε		
λζ	δ	νε		
͵ατξθ	͵ρμη	͵βλε		
	͵ρμη	ιϛ	σκ	
		͵βλε	σκ	
				͵γκε
͵ατοε	δ	ιδ	ι	κε

Here in the first line, λζ multiplied into λζ in the place of units, gives ατξθ or *thirteen hundred and sixty-nine* degrees; λζ into δ on the next bar, gives ρμη, or *one hundred and forty-eight* minutes; and λζ into νε on the lowest bar gives ͵βλε, or *two thousand and thirty-five* seconds. In the second line δ multiplied into λζ gives the product ρμη as before; δ multiplied into δ, both of them on the bar of minutes, gives ιϛ or *sixteen* seconds; δ into νε gives σκ, or *two hundred and twenty* thirds. Lastly, in the third line the νε on the bar of seconds, multiplied successively into λζ, and δ, produce, as before, ͵βλε and σκ on the bars of seconds and thirds; and νε multiplied by itself gives ͵γκε, or *three thousand and twenty-five* fourths. These several products being reduced and collected together, formed the total amount of ͵ατοε δ ιδ ι κε, or *thirteen hundred and seventy-five* degrees, *four* minutes, *fourteen* seconds, *ten* thirds, and *twenty-five* fourths; but all the terms below seconds were omitted in practice as insignificant.

This calculation is laborious and intricate, yet with a very few terms it approaches to a considerable degree of accuracy. One of the most elegant theorems in elementary geometry demonstrates that the side of a regular decagon, inscribed in a circle, is equal to the segment of the radius, divided in extreme and mean ratio. Wherefore the square now computed should be equal to the product of *sixty*, or the radius, into *twenty-two* degrees, *fifty-five* minutes, and *five* seconds, the smaller segment; that is, equal to *thirteen hundred* and *seventy-five* degrees and *five* minutes, from which it differs only by the defect of less than one minute.

The Sexagesimal Arithmetic was, therefore, a most valuable improvement engrafted on the notation of the Greeks. The astronomers of Alexandria and Constantinople continued to employ it in all their calculations, and were afterwards imitated by succeeding observers among the Arabians and Persians. The mode of working sexagesimals had thus become generally known and reduced to practice; but we owe the first distinct treatise on those fractions to a very extraordinary character,—Barlaam, a Calabrian monk, the friend and Greek preceptor of the famous Petrarch, and a man of learning and vigorous intellect, who laboured by his writings and his missions to re-unite the Eastern to the Western church. This adventurous personage, whose wayward conduct and dark features betrayed a lurking ferocity, met with a most singular fate. Being overtaken by a tremendous thunder-storm, while crossing the Adriatic Sea, he lashed himself to the mast of the bark, and was, in this situation, struck dead by a flash of lightning. The event happened in 1348; but Barlaam's tract on sexagesimals, neatly composed in six books, after the strict manner of the ancients, and entitled generally Λογιστικη, or *Computation*, first appeared in a Latin version at Strasburg in 1572, though not published complete with the Greek text until the year 1600, when it was edited at Paris by Chambers of Eton, from a manuscript procured from the Continent by the zeal of Sir Henry Savile.

To facilitate the operations with sexagesimals, it seemed indispensable to have a more extensive multiplication table, that should include the mutual products of all the numbers from one to sixty. This was actually constructed about the middle of the sixteenth century by Philip Lansberg, a Dutch clergyman, and has been exhibited since in various forms by Dr Wallis and others. In the mean time a material change had been effected in the subdivision of the radius of the circle, from which the sexagesimal system had taken its rise. Purbach, the great restorer of mathematical science, instead of making the radius to consist of 216,000 seconds, as Ptolemy and succeeding astronomers had done, stopt short at sixty degrees, and distinguished each of these by a repeated centesimal division, into ten thousand equal parts. Regiomontanus advanced a step farther, and, rejecting the sexagesimal admixture, divided the radius at once into a million of parts, thus following out an arrangement purely decimal. The subdivision into degrees, minutes, and seconds, was henceforth confined to the circumference itself; and when logarithms came afterwards to be adapted to those fractions, they received the appellation, once general, though now restricted, of *Logistic*. But the sexagesimal subdivision had nearly been rejected altogether. Our very meritorious countryman Mr Briggs, in computing his canon of logarithms, followed in another branch the example of Purbach, by distinguishing each degree of the circumference into *an hundred* minutes, and each of these again into *an hundred* seconds; and we cannot help regretting that this easy and obvious improvement had not been generally embraced at the time it was proposed. The French mathematicians have lately gone farther, and endeavoured to pursue to its utmost extent the decimal subdivision first introduced by Regiomontanus. They begin with dividing the quadrant into *an hundred* instead of ninety degrees; and then following the plan of Briggs, they successively divide each degree into *an hundred* minutes, and each minute into *an hundred* seconds. But the advantages which might arise from the adoption of this plan are not sufficient perhaps to outweigh the manifest inconvenience that must attend it in the present advanced state of the science; and notwithstanding the sanguine dreams of some of its projectors, we cannot indulge the expectation of ever seeing it obtain a general and durable currency.

"The Greek arithmetic, then, as successively mould-

ed by the ingenuity of Archimedes, of Apollonius, and Ptolemy, had attained, on the whole, to a singular degree of perfection, and was capable, notwithstanding its cumbrous structure, of performing operations of very considerable difficulty and magnitude. The great and radical defect of the system consisted in the want of a general mark analogous to our cipher; and which, without having any value itself, should serve to ascertain the rank or power of the other characters, by filling up the vacant places in the scale of numeration. Yet were the Greeks not altogether unacquainted with the use of such a sign; for Ptolemy, in his *Almagest*, employs the small o to occupy the accidental blanks which occurred in the notation of sexagesimals. This letter was perhaps chosen by him, because immediately succeeding to ν, which denotes 60, it could not, in the sexagesimal arrangement, occasion any sort of ambiguity. But the advantage thence resulting was entirely confined to that particular case. The letters, being already significant, were generally disqualified for the purpose of a mere supplementary notation; and the selection of an alphabetic character to supply the place of the cipher may be considered as an unfortunate circumstance, which appears to have arrested the progress towards a better and more complete system. Had Apollonius classed the numerals by denary triads instead of tetrads, he would have greatly simplified the arrangement, and avoided the confusion arising from the admixture of the punctuated letters expressing thousands. It is by this method of proceeding with periods of three figures, or advancing at once by thousands instead of tens, that we are enabled most expeditiously to read off the largest numbers. The extent of the alphabet was favourable to the first attempts at enumeration; since, with the help of three intercalations, it furnished characters for the whole range below a thousand; but that very circumstance in the end proved a bar to future improvements. It would have been a most important stride to have next exchanged those triads into monads, by discarding the letters expressive of tens and hundreds, and retaining only the first class, which, with its inserted *episêmon*, should denote the nine digits. The *iôta*, which signified ten, now losing its force, might have been employed as a convenient substitute for the cypher. By such progressive changes the arithmetical notation of the Greeks would at last have reached its utmost perfection, and have exactly resembled our own. A wide interval no doubt did still remain; yet the genius of that acute people, had it continued unfettered, would in time, we may presume, have triumphantly passed the intervening boundaries. But the death of Ptolemy was succeeded by ages of languor and decline; and the spirit of discovery insensibly evaporated in miserable polemical disputes, till the fair establishment of Alexandria was finally overwhelmed under the irresistible arms of the Arabs, lately roused to victory and conquest by the enthusiasm of a new religion." (*Edinburgh Review*, vol. xviii. p. 203.)

History of the Denary numerals.

The ingenuity and varied resources of the ancient Greeks were the main causes which diverted them from discovering our simple denary system. Having attained a distinct conception of the powers of the geometrical progression, and even advanced so far as to employ their small o to fill the breaks of a period, nothing seemed wanting but to dismiss the punctuated letters, and those for tens and for hundreds, and to retain merely the direct symbols for units, that is, the first third part of their alphabet. Here, however, those masters of science were stopt in their career; and the Eastern Empire presents a melancholy picture of the decline and corruption of human nature. Ingenuity had degenerated into polemical subtlety, and the manly virtues which freedom inspires were exchanged for meanness and self-abasement.

Some writers, misled by very superficial views of the subject, have yet ascribed the invention of the modern numeral characters to the Greeks, or even to the Romans. Both these people, for the sake of expedition, occasionally used contractions, especially in representing the numbers and fractions of weights or measures, which, to a credulous peruser of mutilated inscriptions, or ancient blurred manuscripts, might appear to resemble the forms of our ciphers. But this resemblance is merely casual, and very far indeed from indicating the adoption of a regular denary notation. The most contracted of the Roman writings was formed by the marks attributed to Tiro or Seneca, while that of the Greeks was mixed with the symbols called *Siglæ;* both of which have exercised the patience and skill of antiquaries and diplomatists. In the latter species of characters were kept the accounts of the revenues of the empress Irene at Constantinople. But the modern Greeks appear likewise to have sometimes used a simpler kind of marks, at least for the low numbers. The continuator of Matthew Paris's *History* relates, that "in the year 1251 died John Basingstoke, archdeacon of Leicester, who brought into England the numeral figures of the Greeks, and explained them to his friends." It is subjoined that they consisted of a perpendicular stroke, with a short line inserted at different heights and at different angles, signifying units on the left and tens on the right side. The figures themselves are scrawled on the margin of the text; but they are evidently so different in their form, and so distinct in their nature, from the modern ciphers, that one cannot help feeling surprise to see an author of any discernment refer the introduction of the latter to Basingstoke.

It cannot be doubted that we derived our knowledge of the numeral digits from the Arabians, who had themselves obtained this invaluable acquisition from their extended communication with the East. Those deserving people who, under the name of Moors or Saracens, had for many centuries cultivated Spain, were most ready to acknowledge their obligation to the natives of India, who, according to Alsephadi, a learned Arabian doctor, boasted of three very different inventions—the composition of the *Golaila Wadamna*, or Pilpay's Fables—the game of chess—and the nine digital characters. Still much obscurity hangs over the whole subject. Two distinct inquiries naturally present themselves:—1, At what period did the Arabians first become acquainted with those characters; and, 2, What is the precise epoch when the knowledge of them was imparted to the Christian nations of Europe. We shall take a short review of both these questions.

Proofs of their Indian origin.

1. Gatterer, the late ingenious and very learned Professor of History at Göttingen, in his *Elements of Universal Diplomacy*, maintains that our ciphers were only primordial letters, invented by Taaut or Theut, and known to the ancient Egyptians and Phœnicians, being still distinctly observed, as he asserts, in the inscriptions painted on the coverings of the oldest mummies; and that afterwards, along with other branches of science, they passed to the Oriental nations, among whom they were preserved, till the victorious arms of the Mussulmen penetrated to India, and brought back those precious monuments of genius. But we cannot believe that a contrivance so very simple, and so eminently useful, as that of the nine digits, if once communicated, could ever again be lost or neglected. Pythagoras and Boethius merely contemplated the properties of numbers, and seem not, in their calculations, to have gone beyond the use of the *Abacus*. An early intercourse had no doubt subsisted between the people of Egypt and of India, and a striking resemblance may be traced in their customs, their buildings, and their

History. religious rites. But the characters exhibited on the Egyptian monuments bear no indication of the *Denary System*, and are, like the Roman and Chinese numerals, abridged representations of objects, rather than arbitrary signs.

That the occupiers of Hindostan, and the nations communicating with them, have for ages been acquainted with the use of the denary notation, cannot be disputed. But was this an original discovery, or at what distant epoch was it first introduced among them? The easy credulity of European visitors encouraged the Brahmins to set up very lofty pretensions respecting the antiquity of their science. Among other treasures, they boasted the possession, from time immemorial, of an elementary treatise on arithmetic and mensuration, composed in Sanscrit, and called *Lilawati*, of such inestimable value as to be ascribed to the immediate inspiration of heaven. But the researches of our ingenious countrymen in exploring that sacred language of India have dispelled some illusions, and greatly abated the admiration of the public for such eastern learning. From what we have been able to gather, the *Lilawati* is a very short and meagre performance, loaded with a silly preamble and colloquy of the gods. It begins with the numeration by nine digits, and the supplementary cipher or small o, in what are called the *Devanagari* characters; and it contains the common rules of arithmetic, and even the extraction of the square root, as far as two places of figures; but the examples are generally very easy, scarcely forming any part of the text, and only written on the margin with red ink. Of fractions, whether decimal or vulgar, it treats not at all.

The Hindoos pretend that this arithmetical treatise was composed about the year 1185 of the Christian era. The date of a manuscript, however, is always very uncertain. We know, besides, that the oriental transcriber is accustomed to incorporate without scruple such additions in the text as he thinks fit. Nor will any of the criteria which might ascertain the age of a manuscript apply to the eastern writings, where the composition of the paper, the colour of the ink, and the form of the characters, have for ages continued unchanged.

If the exuberant fancy of the Greeks led them far beyond the denary notation, it seems probable that the feebler genius of the Hindoos might just reach that desirable point, without diverging into an excursive flight. Though now familiar with that system, they are still unacquainted with the use of its descending decimal scale; and their management of fractions, accordingly, is said by intelligent judges to be tedious and embarrassed. In Plate LXXVI. (on the left hand, and near the bottom), we have given the Sanscrit digits, and have placed over them the numeral elements from which they might be formed. These consist of a succession of simple strokes, variously combined as far as nine. The resemblance to the *Devanagari* characters appears very striking. From these, again, the common Hindoo and the vulgar Bengalee digits are evidently moulded, with only slight alterations of figure. The Birman numerals, which we have copied from Symes's *Embassy to the Kingdom of Ava*, are manifestly of the same origin; only they have a thin, wirey body, being generally written on the palmyra-leaf with the point of a needle.

It appears, from a careful inspection of the manuscripts preserved in the different public libraries of Europe, that the Arabians were not acquainted with the denary numerals before the middle of the thirteenth century of the Christian era. They cultivated the mathematical sciences with ardour, but seldom aspired at original efforts, and generally contented themselves with copying their Grecian masters. The alphabet of the Arabians had been employed for expressing numbers exactly in the same way as that of the Greeks. The letters, in their succession, were sometimes applied to signify the lower of the ordinal numbers; but more generally they were distinguished into three classes, each composed of nine characters, corresponding to units, tens, and hundreds. Though, like most of the Oriental nations, the Arabians write from right to left, yet they followed implicitly the Greek mode of ranging the numerals and performing their calculations. With the same deference they received the other lessons of their great masters, and very seldom hazarded any improvement, unless where industry and patient observation led them incidentally to extend mensuration, and to rectify and enlarge the basis of astronomy.

It seems highly probable, therefore, that the Arabians did not adopt the Indian numerals until a late period, and after the torrent of victory had opened an easy communication with Hindostan. They might derive their information through the medium of the Persians, who spoke a dialect of their language, had embraced the same religion, and were, like them, inflamed by the love of science and the spirit of conquest. The Arabic numerals, accordingly, resemble exceedingly the Persic, which are now current over India, and there esteemed the fashionable characters. But the Persians themselves, though no longer the sovereigns of Hindostan, yet display their superiority over the feeble Gentoos, since they generally fill the offices of the revenue, and have the reputation of being the most expert calculators in the East. It should be observed, however, that, according to Gladwin, these accountants have introduced a peculiar contracted mode of registering very large sums, partly by the numeral characters, and partly by means of symbols formed of abbreviated words. Yet Sir John Chardin relates that the Persians have no proper terms to express numbers beyond a thousand, which they merely repeat, as our young arithmeticians often do, to signify a million or a billion.

The Indian origin of the denary numerals is farther confirmed by the testimony of Maximus Planudes, a monk of Constantinople, who wrote, about the middle of the fourteenth century, a book on practical arithmetic, entitled Λογιστικη Ινδικη, or Ψηφοφορια κατ' Ινδες, ἡ λεγομενη μεγαλη, that is, "the great Indian mode of calculating." In his introduction he explains concisely the use of the characters in notation. But Planudes appears neither to have received his information directly from India, nor through the medium of the Persians, the nearest neighbours on the eastern confines of the Greek empire. It is most probable that he was made acquainted with those numerals by his intercourse with Europe, having twice visited, on a sort of embassy, the Republic of Venice; for, of two manuscripts preserved in the library of St Mark, the one has the characters of the Arabians, and the other has that variety which was first current in Europe, while neither of them shows the original characters used in Hindostan.

Their introduction into Europe.

2. But the most important inquiry is to ascertain the period at which the knowledge of our present numerals was first spread over Europe. As it certainly had preceded the invention of the art of printing, the difficulty of resolving the question is much increased by the necessity of searching and examining old and often doubtful manuscripts. Some authors would date the introduction of those ciphers as early as the beginning of the eleventh century, while others, with far greater appearance of reason, are disposed to place it 250 years later.

While the thickest darkness brooded over the Christian world, the Arabians, reposing after their brilliant conquests, cultivated with assiduity the learning and science of Greece. If they contributed little from their own

store of genius, they yet preserved and fanned the holy fire. Nor did they affect any concealment, but would freely communicate to their pupils and visitors that precious knowledge which they had so zealously drawn from different quarters. Some of the more aspiring youth in England and France, disgusted with the wretched trifling of the schools, resorted for information to Spain; and having the courage to subdue the rooted abhorrence entertained in that age against infidels, took lessons in philosophy from the accomplished Moors. Among those pilgrims of science, the most celebrated was Gerbert, a monk, born of obscure parents, at Aurillac, in Auvergne, but promoted by his talents successively to the bishoprics of Rheims and of Ravenna, and finally raised to the papal chair, which he filled during the last four years of the tenth century, under the name of Sylvester II. This ardent genius studied arithmetic, geometry, and astronomy among the Saracens; and, on his return to France, charged with various knowledge, he was esteemed a prodigy of learning by his contemporaries. Nor did the malice of rivals fail to represent him as a magician, leagued with the infernal powers. Gerbert wrote largely on arithmetic and geometry, and gave rules for shortening the operations of the *Abacus*, which he likewise termed *Algorismus*. In some manuscripts the numbers are expressed in ciphers; but we are not thence entitled to infer, as many writers have done, that he had actually the merit of introducing those characters into Europe. The context of his discourse will not support such a conclusion. The figures were not, we have seen, still known to the Arabians themselves; and must have long afterwards been inserted in those copies for the convenience of transcribers.

Nor can we safely refer the introduction of Arabic figures to our famous Roger Bacon, whose various attainments and unwearied research after genuine knowledge raised him far above the level of his contemporaries, but who, to the disgrace of his age and country, suffered a sharp persecution and a tedious imprisonment, on the ridiculous charge of practising the redoubted acts of magic. But the writings of Bacon really discover no proofs of his acquaintance with the denary notation; and the fact commonly stated as an irresistible evidence in his favour bears a very different interpretation. An almanack, now preserved in the Bodleian Library at Oxford, and containing numerals in their earliest forms, has, by the credulity of after-times, been, with all other feats and inventions, ascribed of course to the great necromancer. But unluckily this production is marked with the date 1292, the very year on which Bacon, after a lingering illness, expired; and it besides professes to have been calculated for the meridian of Toulouse, and had consequently been imported without doubt from France.[1]

About the same period John of Halifax, named, in the quaint Latinity then used, *Sacro-Bosco*, who had likewise travelled, wrote his treatise *De Sphæra*, in some copies of which the numbers are given in ciphers. But it appears from examination that such abbreviations were introduced by the license of transcribers.

There is little doubt that the Arabic figures were first used by astronomers, and afterwards circulated in the almanacks over Europe. The learned Gerard Vossius places this epoch about the year 1250; but the judicious and most laborious Du Cange thinks that ciphers were unknown before the fourteenth century; and Father Mabillon, whose diplomatic researches are immense, assures us that he very rarely found them in the dates of any writings prior to the year 1400. Kircher, with some air of probability, seeks to refer the introduction of our numerals to the astronomical tables which, after vast labour and expense, were published by the famous Alphonso, king of Castile, in 1252, and again more correctly four years afterwards. But it is suspected that, in the original work, the numbers were expressed in Roman or Saxon characters. Two letters from that enlightened but ill-requited prince, to our Edward I., which are preserved in the Tower of London, have the dates 1272 and 1278 still denoted by those ancient characters.

In the tenth volume of the *Archæologia*, the Rev. Mr North has given a short account of an almanack preserved in the library of Bennet College, Cambridge, and containing a table of eclipses for the cycle between 1330 and 1348. There is prefixed to it a very brief explication of the use of numerals, and the principles of the denary notation; from which we may see how imperfectly the practice of those ciphers was then understood. The figures are of the oldest form, but differ not materially from the present, except that the four has a looped shape, and the five and seven are turned about to the left and to the right. The one, two, three, and four, are likewise, perhaps for elucidation, represented by so many dots thus, . .. ∴ ∷; while five, six, seven, and eight, are signified by a semicircle or inverted ↄ with the addition of corresponding dots—ↄ. ↄ: ↄ∴. Nine is denoted by o; ten by the same character with a dash drawn across it; and twenty, thirty, or forty, by this last symbol repeated.

As a farther evidence of the inaccurate conceptions which prevailed respecting the use of the digits in the fourteenth century, we may refer to the mixture of Saxon and Arabic numerals which was copied from some French manuscripts by Mabillon, as exhibited in Plate LXXVI. The Saxon ᵡ, signifying ten, is repeatedly combined with the ordinary figures; and ᵡᵡᵡ, ᵡᵡᵡi, are immediately followed by 302, and 303, which must have been therefore intended to signify *thirty-two* and *thirty-three*, the force of the cipher not being still rightly understood. It should be observed, that the Greek *episémon* or *Fau*, for the number *six*, had come to be represented by a character similar to G. The Saxon dates are taken from the Danish and Norwegian registers, preserved in Suhm's *Northern Collections*.

One of the oldest authentic dates in the numeral characters is that of the year 1375, which appears written by the hand of the famous Petrarch on a copy of St Augustine that had belonged to that distinguished poet and philosopher. The use of those characters had now begun to spread in Europe, but was still confined to men of learning. We have seen a short tract in the German language, entitled *De Algorismo*, and bearing the date 1390, which explained with great brevity the digital notation

[1] Nothing appears to be worse founded than the attempts to represent the elder Bacon in the light of an original inventor. Notwithstanding the obscurity of his writings, it needs but a little criticism to dispel the conceits fomented by national partiality. Friar Bacon advances no claim even to the discovery of gunpowder, which has been so gratuitously ascribed to him. On the contrary, he admits that the boys in his time were acquainted with the use of this substance in fire-works; and he merely pretends, in a sort of anagram, to give a receipt for making it stronger and better than ordinary.

After the chief ingredient in the composition of gunpowder, under the mistaken names of *natron* or *nitrum*, and *saltpetre* or *rock-salt*, had been imported from the East, probably through the intervention of the Crusaders, its disposition to explode in the contact of inflammable matters, if not communicated along with it, could not remain for any time a secret. The explosive force was a very different and a far more important property, which is perhaps rightly attributed to Schwartz, a German monk, who, in the course of his experiments, stumbled on it about the middle of the fourteenth century.

History. and the elementary rules of arithmetic. What is very remarkable, the characters in their earliest form are ranged thus, 0, 9, 8, 7, 6, 5, 4, 3, 2, 1, from right to left, the order which the Arabians would naturally follow. But it was not very easy to comprehend at first the precise force of the *cipher*, which, insignificant by itself, only serves to determine the rank and value of the other digits. The name, derived from an Arabic word signifying *vacuity*, is sufficiently expressive; yet a sort of mystery, which has imprinted its trace on language, seemed to hang over the practice, for we still speak of *deciphering*, and of *writing in cipher*, in allusion to some dark or concealed art. After the digits had come to supply the place of the Roman numerals, a very considerable time probably elapsed before they were generally adopted in calculation. The modern practice of arithmetic was unknown in England till about the middle of the sixteenth century. But the lower orders, imitating the clerks of a former age, were still accustomed to reckon with their *counters* or *awgrym stones*. In Shakspeare's comedy of the *Winter's Tale*, written at the commencement of the seventeenth century, the clown, staggered with a very simple multiplication, exclaims, that he will try it with counters.

Arithmetic was long considered in England as a higher branch of science, and therefore left, like Geometry, to be studied at the university. Most of the public or grammar schools of the south were, on the suppression of the monasteries, erected a little after the Reformation, during the short but auspicious reign of Edward VI. They were accordingly destined by their founders merely for teaching the dead languages; and the too exclusive pursuit of the same system is now one of the greatest defects in the English plan of liberal education.

It cannot be doubted that the calendars composed in France or Germany, and sent to the different religious houses, were the means of dispersing the knowledge of Arabic numerals over Europe. The library of the University of Edinburgh has a very curious almanack, presented to it, with a number of other valuable tracts, by the celebrated Drummond of Hawthornden, beautifully written on vellum, with most of the figures in vermillion. It is calculated especially for the year 1482, but contains the succession of lunar phases for three cycles, 1475, 1494, and 1513, with the visible eclipses of the sun and moon from 1482 to 1530 inclusive. The date of this precious manuscript, which had once belonged to St Mary's Abbey at Cupar in Angus, is easily determined, and we have copied from it the oldest numerals exhibited in Plate LXXVI. To these we have subjoined *fac-similes* from Caxton's *Mirrour of the World*, and a wooden cut from Shirwood's *Ludus Arithmomachiæ*, given in Dibdin's *Bibliotheca Spenceriana*.

The college accounts in the English universities were generally kept in the Roman numerals till the early part of the sixteenth century; nor in the parish registers were the Arabic characters adopted before the year 1600. The oldest date which we have met with in Scotland is that of 1490, which occurs in the rent-roll of the diocese of St Andrews; the change from Roman to Arabic numerals occurring, with a corresponding alteration in the form of the writing, near the end of the volume. The old characters in Plate LXXVI. are copied from a manuscript history of the Scotish Bishoprics, apparently written about the year 1550, and now in the possession of Thomas Thomson, Esq. advocate.[1] (B.)

II.—OPERATIONS OF ARITHMETIC.

Chap. I.—Notation and Numeration.

Notation and Numeration.

The first elements of arithmetic are acquired during our infancy. The idea of *one* is the simplest of any, and is suggested by every single object. *Two* is formed by placing one object near another; *three*, *four*, and every higher number, by adding one continually to the former collection. As we thus advance from lower numbers to higher, we soon perceive that there is no limit to this increasing operation; and that, whatever number of objects be collected together, more may be added, at least in imagination; so that we can never reach the highest possible number, nor approach near it. The idea of numbers, which is first acquired by the observation of sensible objects, is afterwards extended to measures of space and time, affections of the mind, and other immaterial qualities.

Small numbers are most easily apprehended: a child soon knows what *two* and what *three* is, but has not any distinct notion of *seventeen*. Experience removes this difficulty in some degree: as we become accustomed to handle larger collections, we apprehend clearly the number of a dozen or a score; but perhaps could hardly advance to a hundred without the aid of systematic arrangement, which is the art of forming so many units into a class, and so many of these classes into one of a higher kind, and thus advancing through as many ranks of classes as occasion requires. If a boy arrange an hundred stones in one row, he would be tired before he could reckon them; but if he place them in ten rows of ten stones each, he will reckon an hundred with ease; and if he collect ten such parcels, he will reckon a thousand. In this case, ten is the lowest class, a hundred is a class of the second rank, and a thousand is a class of the third rank.

There does not seem to be any number naturally adapted for constituting a class of the lowest or any higher rank, to the exclusion of others. However, as ten has been universally used for this purpose by the Hebrews, Greeks, Romans, and Arabians, and by all nations who have cultivated this science, it is probably the most convenient for general use; but other scales may be assumed, perhaps, on some occasions with superior advantage; and the principles of arithmetic will appear in their full extent, if the student can adapt them to any scale whatever. Thus, if eight were the scale, 6 times 3 would be two classes and two units, and the number 18 would then be represented by 22. If 12 were the scale, 5 times 9 would be three classes and nine units, and 45 would be represented by 39.

Whatever number of units constitutes a class of the lower rank, the same number of each class should make one of the next higher. This is observed in our arithmetic, ten being the universal scale; but it is not regarded in the various kinds of monies, weights, and the like, which do not advance by any universal measure; and much of the difficulty in the practice of arithmetic arises from that irregularity.

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[1] For want of attending to these facts, some learned antiquaries have often suffered themselves to be grossly misled. Thus, Mr De Cardonnel, a respectable author, who has given views and short descriptions of the ancient edifices in Scotland, mentions, without marking the smallest doubt or surprise, that the date 1155 appears over the gateway of the ruins of the Castle of St Andrews. But this front was built subsequent to the murder of the detested Cardinal Beaton, by Archibald Hamilton, who likewise there affixed his arms, but who long afterwards, on the capture of Dumbarton Castle, suffered an ignominious death, for his adherence to Queen Mary and the Popish faction. The real date was unquestionably 1555, only the second figure has been almost effaced by time and accident.

Notion of Numeration.

As higher numbers are somewhat difficult to apprehend, we naturally fall on contrivances to fix them in our minds, and render them familiar; but notwithstanding all the expedients we can fall upon, our ideas of high numbers are still imperfect, and generally far short of the reality; and though we can perform any computation with exactness, the answer we obtain is often incompletely apprehended.

It may not be amiss to illustrate, by a few examples, the extent of numbers which are frequently named without being attended to. If a person employed in telling money reckon an hundred pieces in a minute, and continue at work ten hours each day, he will take seventeen days to reckon a million; a thousand men would take 45 years to reckon a billion. If we supposed the whole earth to be as well peopled as Britain, and to have been so from the creation, and that the whole race of mankind had constantly spent their time in telling from a heap consisting of a quadrillion of pieces, they would hardly have yet reckoned the thousandth part of that quantity.

All numbers are represented by the ten following characters.

1 2 3 4 5 6 7 8 9 0

One, two, three, four, five, six, seven, eight, nine, cipher.

The nine first are called *significant figures*, or *digits;* and sometimes represent units, sometimes tens, hundreds, or higher classes. When placed singly, they denote the simple numbers subjoined to the characters; when several are placed together, the first or right-hand figure only is to be taken for its simple value; the second signifies so many tens, the third so many hundreds, and the others so many higher classes, according to the order they stand in. And as it may sometimes be required to express a number consisting of tens, hundreds, or higher classes, without any units or classes of a lower rank annexed, and as this can only be done by figures standing in the second, third, or higher places, while there are none to fill up the lower ones; therefore an additional character or cipher (0) is necessary, which has no signification when placed by itself, but serves to supply the vacant places, and bring the figures to their proper station.

The following table shows the names and divisions of the classes.

8.	4.	3	7,	9	8	2.	5	6	4,	7	3	8.	9	7	2,	6	4	5.
Trillions						Billions						Millions						
	Hundred thousand of billions	Ten thousand of billions	Thousand billions	Hundred billions	Ten billions		Hundred thousand of millions	Ten thousand of millions	Thousand millions	Hundred millions	Ten millions		Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Units

The first six figures from the right hand are called the *unit period*, the next six the *million period*, after which the *trillion*, *quadrillion*, *quintillion*, *sextillion*, *septillion*, *octillion*, and *nonillion* periods follow in their order.

It is proper to divide any number, before we reckon it, into periods and half periods, by different marks. We then begin at the left hand, and read the figures in their order, with the names of their places, from the table. In writing any number, we must be careful to mark the figures in their proper places, and supply the vacant places with ciphers.

Addition.

As there are no possible ways of changing numbers, except by enlarging or diminishing them according to some given rule, it follows that the whole art of arithmetic is comprehended in two operations, *Addition* and *Subtraction*. However, as it is frequently required to add several equal numbers together, or to subtract several equal ones from a greater, till it be exhausted, proper methods have been invented for facilitating the operation in these cases, and distinguished by the names of *Multiplication* and *Division;* and these four rules are the foundation of all arithmetical operations whatever.[1]

As the idea of number is acquired by observing several objects collected, so is that of fractions by observing an object divided into several parts. As we sometimes meet with objects broken into two, three, or more parts, we may consider any or all of these divisions promiscuously, which is done in the doctrine of vulgar fractions. However, since the practice of collecting units into parcels of tens has prevailed universally, it has been found convenient to follow a like method in the consideration of fractions, by dividing each unit into ten equal parts, and each of these into ten smaller parts; and so on. Numbers divided in this manner are called *Decimal Fractions.*

Chap. II.—Addition.

Addition is that operation by which we find the amount of two or more numbers. The method of doing this in simple cases is obvious, as soon as the meaning of number is known, and admits of no illustration. A young learner will begin at one of the numbers, and reckon up as many units separately as there are in the other, and practice will enable him to do it at once. It is impossible, strictly speaking, to add more than two numbers at a time. We must first find the sum of the first and second, then we add the third to that number, and so on. However, as the several sums obtained are easily retained in the memory, it is neither necessary nor usual to mark them down. When the numbers consist of more figures than one, we add the units together, the tens together, and so on. But if the sum of the units exceed ten, or contain ten several times, we add the number of tens it contains to the next column, and only set down the number of units that are over. In like manner we carry the tens of every column to the next higher. And the reason of this is obvious from the value of the places; since an unit, in any higher place, signifies the same thing as ten in the place immediately lower.

Rule.—*Write the numbers distinctly, units under units, tens under tens, and so on. Then reckon the amount of the right-hand column. If it be under ten, mark it down. If it exceed ten, mark the units only, and carry the tens to the next place. In like manner, carry the tens of each column to the next, and mark down the full sum of the left-hand column.*

Example.

346863
876734
123467
314213
712316
438987
279654
3092234
24433

As it is of great consequence in business to perform addition readily and exactly, the learner ought to practise it till it become quite familiar. If the learner can readily add any two digits, he will soon add a digit to a higher number with equal ease. It is only to add the unit place

[1] To abbreviate, it is sometimes convenient to indicate the four operations of arithmetic by the signs +, —, ×, ÷. The first, +, denotes addition; the second, —, indicates subtraction; the third, ×, multiplication; and the fourth, ÷ division. The sign = put between two quantities indicates that they are equal. Accordingly we may write $2 + 3 = 5$; $7 - 3 = 4$; $5 \times 3 = 15$; $14 \div 2 = 7$.

of that number to the digit; and if it exceed ten, it raises the amount accordingly. Thus, because 8 and 6 are 14, 48 and 6 are 54. It will be proper to mark down under the sums of each column, in a small hand, the figure that is carried to the next column. This prevents the trouble of going over the whole operation again, in case of interruption or mistake. If you wish to keep the account clean, mark down the sum and figure you carry on a separate paper, and after revising them, transcribe the sum only. After some practice, we ought to acquire the habit of adding two or more figures at one glance. This is particularly useful when two figures which amount to 10, as 6 and 4, or 7 and 3, stand together in the column.

Every operation in arithmetic ought to be revised, to prevent mistakes; and as one is apt to fall into the same mistake, if he revise it in the same manner he performed it, it is proper either to alter the order, or else to trace back the steps by which the operation advanced, which will lead us at last to the number we began with. Every method of proving accounts may be referred to one or other of these heads.

1*st*, Addition may be proved by any of the following methods: Repeat the operation, beginning at the top of the column, if you began at the foot when you wrought it.

2*d*, Divide the account into several parts; add these separately, and then add the sums together. If their amount correspond with the sum of the account when added at once, it may be presumed right. This method is particularly proper when you want to know the sums of the parts as well as that of the whole.

3*d*, Subtract the numbers successively from the sum; if the account be right, you will exhaust it exactly, and find no remainder.

When the given number consists of articles of different value, as pounds, shillings, and pence, or the like, which are called *different denominations*, the operations in arithmetic must be regulated by the value of the articles. We shall give here a few of the most useful tables.

I. *Sterling Money.*	II. *Avoirdupois Weight.*
4 farthings = 1 penny, *marked* d.	16 drams = 1 ounce, oz.
	16 ounces = 1 pound, lb.
12 pence = 1 shilling, s.	28 pounds = 1 quarter, qr.
20 shillings = 1 pound, £.	4 quart. = 1 hundredw^t, cwt.
Also 6s. 8d. = 1 noble.	20 hundredw^t = 1 ton, T.
12s. = 1 angel.	
13s. 4d. or two thirds of a pound = 1 merk.	

Scots money is divided in the same manner as sterling, and has one twelfth of its value. A pound Scots is equal to 1s. 8d. sterling, a shilling Scots to a penny sterling, and a penny Scots to a twelfth part of a penny sterling; a merk Scots is two thirds of a pound Scots, or 13⅓d. sterling.

III. *Troy Weight.*	IV. *Apothecaries' Weight.*
20 mites = 1 grain, gr.	20 grains = 1 scruple, ℈
24 grains = 1 pennyw^t, dwt.	3 scruples = 1 dram, ʒ
20 pennyw^{ts} = 1 ounce, oz.	8 drams = 1 ounce, ℥
12 ounces = 1 pound, lib.	12 ounces = 1 pound, ℔.

V. *English Dry Measure.*	VI. *Scots Dry Measure.*
2 pints = 1 quart	4 lippies = 1 peck
4 quarts = 1 gallon	4 pecks = 1 firlot
2 gallons = 1 peck	4 firlots = 1 boll
4 pecks = 1 bushel	16 bolls = 1 chalder
8 bushels = 1 quarter	

VII. *English Land Measure.*	VIII. *Scots Land Measure.*
30¼ square yards = 1 pole or perch	36 square ells = 1 fall
40 poles = 1 rood	40 falls = 1 rood
4 roods = 1 acre	4 roods = 1 acre

IX. *Long Measure.*	X. *Time.*
12 inches = 1 foot	60 seconds = 1 minute
3 feet = 1 yard	60 minutes = 1 hour
5½ yards = 1 pole	24 hours = 1 day
40 poles = 1 furlong	7 days = 1 week
8 furlongs = 1 mile	365 days = 1 year
3 miles = 1 league	52 weeks and 1 day = 1 year

Rule for Compound Addition.—*Arrange like quantities under like, and carry according to the value of the higher place.*

Note 1. When you add a denomination which contains more columns than one, and from which you carry to the higher by 20, 30, or any even number of tens, first add the units of that column, and mark down their sum, carrying the tens to the next column; then add the tens, and carry to the higher denomination, by the number of tens that it contains of the lower. For example, in adding shillings, carry by 10 from the units to the tens, and by 2 from the tens to the pounds.

Note 2. If you do not carry by an even number of tens, first find the complete sum of the lower denomination, then inquire how many of the higher that sum contains, and carry accordingly, and mark the remainder, if any, under the column. For example, if the sum of a column of pence be 43, which is three shillings and sevenpence, mark 7 under the pence column, and carry 3 to that of the shillings.

Note 3. Some add the lower denominations after the following method: when they have reckoned as many as amounts to one of the higher denomination, or upwards, they mark a dot, and begin again with the excess of the number reckoned above the value of the denomination. The number of dots shows how many are carried, and the last reckoned number is placed under the column.

Examples.

Sterling Money.			*Avoirdupois Weight.*			
£	s.	d.	T.	cwt.	qr.	lb.
127	13	3	3	15	2	24
43	5	10½	6	3	0	19
806	18	7	5	7	3	26
190	2	5¾	3	2	2	0
214	0	3	4	3	1	10
85	15	4½	1	18	1	12
1467	15	9¾	24	11	0	7

Chap. III.—Subtraction.

Subtraction is the operation by which we take a lesser number from a greater, and find their difference. It is exactly opposite to addition, and is performed in a like manner, beginning at the greater, and reckoning downwards the units of the lesser. The greater is called the *minuend*, and the lesser the *subtrahend*.

If any figure of the subtrahend be greater than the corresponding figure of the minuend, we add ten to that of the minuend, and having found and marked the difference, we add one to the next place of the subtrahend. This is called *borrowing ten*. The reason will appear, if we consider that, when two numbers are equally increased by adding the same to both, their difference will not be altered. When we proceed as directed above, we add ten to the minuend, and we likewise add one to the higher place of the subtrahend, which is equal to ten of the lower place.

Rule.—*Subtract units from units, tens from tens, and so on. If any figure of the subtrahend be greater than the corresponding one of the minuend, borrow ten.*

Example.			
	Minuend	173694	738641
	Subtrahend	21453	379235
	Remainder	152241	359406

Subtraction.

To prove subtraction, add the subtrahend and remainder together; if their sum be equal to the minuend, the account is right.

Or subtract the remainder from the minuend. If the difference be equal to the subtrahend, the account is right.

Rule for Compound Subtraction.—*Place like denominations under like; and borrow, when necessary, according to the value of the higher place.*

Examples.

£	s.	d.	Cwt.	qr.	lib.	A.	R.	F	E.
146	3	3	12	3	19	15	2	24	18
58	7	6	4	3	24	12	2	36	7
87	15	9	7	3	23	2	3	28	11

Note 1. The reason for borrowing is the same as in simple subtraction. Thus, in subtracting pence, we add 12 pence when necessary to the minuend, and at the next step we add one shilling to the subtrahend.

Note 2. When there are two places in the same denomination, if the next higher contain exactly so many tens, it is best to subtract the units first, borrowing ten when necessary; and then subtract the tens, borrowing, if there is occasion, according to the number of tens in the higher denomination.

Note 3. If the value of the higher denomination be not an even number of tens, subtract the units and tens at once, borrowing according to the value of the higher denomination.

Note 4. Some choose to subtract the place in the subtrahend, when it exceeds that of the minuend, from the value of the higher denomination, and add the minuend to the difference. This is only a different order of proceeding, and gives the same answer.

Multiplication.

Note 5. As custom has established the method of placing the subtrahend under the minuend, we follow it when there is no reason for doing otherwise; the minuend may be placed under the subtrahend with equal propriety; and the learner should be able to work it either way with equal readiness, as this last is sometimes more convenient, of which instances will occur afterwards.

Note 6. The learner should also acquire the habit, when two numbers are marked down, of placing such a number under the lesser, that, when added together, the sum may be equal to the greater. The operation is the same as subtraction, though conceived in a different manner, and is useful in balancing accounts and on other occasions.

Chap. IV.—Multiplication.

In multiplication two numbers are given, and it is required to find how much the first amounts to when reckoned as many times as there are units in the second. Thus, 8 multiplied by 5, or 5 times 8, is 40. The given numbers (8 and 5) are called *factors*, the first (8) the *multiplicand*, the second (5) the *multiplier*, and the amount (40) the *product*.

This operation is nothing else than addition of the same number several times repeated. If we mark 8 five times under each other, and add them, the sum is 40. But as this kind of addition is of frequent and extensive use, in order to shorten the operation, we mark down the number only once, and conceive it to be repeated as often as there are units in the multiplier.

For this purpose the learner must be thoroughly acquainted with the following multiplication table, which is composed by adding each digit twelve times.

Twice		Thrice		Four times		Five times		Six times		Seven times		Eight times		Nine times		Ten times		Eleven times		Twelve times	
1 is	2	1 is	3	1 is	4	1 is	5	1 is	6	1 is	7	1 is	8	1 is	9	1 is	10	1 is	11	1 is	12
2	4	2	6	2	8	2	10	2	12	2	14	2	16	2	18	2	20	2	22	2	24
3	6	3	9	3	12	3	15	3	18	3	21	3	24	3	27	3	30	3	33	3	36
4	8	4	12	4	16	4	20	4	24	4	28	4	32	4	36	4	40	4	44	4	48
5	10	5	15	5	20	5	25	5	30	5	35	5	40	5	45	5	50	5	55	5	60
6	12	6	18	6	24	6	30	6	36	6	42	6	48	6	54	6	60	6	66	6	72
7	14	7	21	7	28	7	35	7	42	7	49	7	56	7	63	7	70	7	77	7	84
8	16	8	24	8	32	8	40	8	48	8	56	8	64	8	72	8	80	8	88	8	96
9	18	9	27	9	36	9	45	9	54	9	63	9	72	9	81	9	90	9	99	9	108
10	20	10	30	10	40	10	50	10	60	10	70	10	80	10	90	10	100	10	110	10	120
11	22	11	33	11	44	11	55	11	66	11	77	11	88	11	99	11	110	11	121	11	132
12	24	12	36	12	48	12	60	12	72	12	84	12	96	12	108	12	120	12	132	12	144

If both factors be under 12, the table exhibits the product at once. If the multiplier only be under 12, we begin at the unit place and multiply the figures in their order, carrying the tens to the higher place, as in addition.

Ex. 76859 multiplied by 4, or 76859 added 4 times.

```
    4          76859
 ------        76859
307436         76859
               ------
               307436
```

If the multiplier be 10, we annex a cipher to the multiplicand; if the multiplier be 100, we annex two ciphers, and so on. The reason is obvious, from the use of ciphers in notation.

If the multiplier be any digit, with one or more ciphers on the right hand, we multiply by the figure, and annex an equal number of ciphers to the product. Thus, if it be required to multiply by 50, we first multiply by 5, and then annex a cipher. It is the same thing as to add the multiplicand 50 times; and this might be done by writing the account at large, dividing the column into 10 parts of 5 lines, finding the sum of each part, and adding these ten sums together.

If the multiplier consists of several significant figures, we multiply separately by each, and add the products. It is the same as if we divided a long account of addition into parts corresponding to the figures of the multiplier.

Example. To multiply 7329 by 365.

```
 7329      7329      7329      36645 =   5 times.
    5        60       300     439740 =  60 times.
 ----      ----      ----    2198700 = 300 times.
36645     439740   2198700    -------   ---
                              2675085 = 365 times.
```

It is obvious that 5 times the multiplicand added to 60 times, and to 300 times the same, must amount to the product required. In practice we place the products at once under each other; and as the ciphers arising from the higher places of the multiplier are lost in the addition, we omit them. Hence may be inferred the following

Multiplication.

RULE.—*Place the multiplier under the multiplicand, and multiply the latter successively by the significant figures of the former, placing the right-hand figure of each product under the figure of the multiplier from which it arises, then add the product.*

Ex.	7329	42785	37846	93956
	365	91	235	8704
	36645	42785	189230	375824
	43974	385065	113538	657692
	21987	3893435	75692	751648
	2675085		8893810	817793024

A number which cannot be produced by the multiplication of two others is called a *prime number;* as 3, 5, 7, 11, and many others.

A number which may be produced by the multiplication of two or more smaller ones, is called a *composite number;* for example, 27, which arises from the multiplication of 9 by 3; and these numbers, 9 and 3, are called the *component parts* of 27.

Contractions and Varieties in Multiplication.

1*st*, If the multiplier be a composite number, we may multiply successively by the component parts.

Ex.	7638 by 45, or 5 times 9	7638
	45	9
	38190	68742
	30552	5
	343710	343710

Because the second product is equal to five times the first, and the first is equal to nine times the multiplicand, it is obvious that the second product must be five times nine, or forty-five times as great as the multiplicand.

2*dly*, If the multiplier be 5, which is the half of 10, we may annex a cipher and divide by 2. If it be 25, which is the fourth part of 100, we may annex two ciphers and divide by 4. Other contractions of the like kind will readily occur to the learner.

3*dly*, To multiply by 9, which is one less than 10, we may annex a cipher, and subtract the multiplicand from the number it composes. To multiply by 99999, or any number of 9's, annex as many ciphers, and subtract the multiplicand. The reason is obvious; and a like rule may be found though the unit place be different from 9.

4*thly*, Sometimes a line of the product is more easily obtained from a former line of the same than from the multiplicand.

Ex. 1*st.*	1372	2*d.*	1348
	84		36
	5488		8088
	10976		4044
	115248		48528

In the first example, instead of multiplying by 8, we may multiply 5488 by 2; and, in the second, instead of multiplying by 3, we may divide 8088 by 2.

5*thly*, Sometimes the product of two or more figures may be obtained at once, from the product of a figure already found.

Ex. 1*st.*	14356	2*d.*	3462321
	648		96484
	114848		13849284
	918784		166191408
	9302688		332382816
			334058579364

In the second example we multiply first by 4, then, because 12 times 4 is 48, we multiply the first line of the product by 12, instead of multiplying separately by 8 and 4; lastly, because twice 48 is 96, we multiply the second line of the product by 2, instead of multiplying separately by 6 and 9.

When we follow this method, we must be careful to place the right-hand figure of each product under the right-hand figure of that part of the multiplier which it is derived from.

It would answer equally well in all cases to begin the work at the highest place of the multiplier; and contractions are sometimes obtained by following that order.

Ex. 1*st.*	3125	or	3125	2*d.*	32452
	642		642		52575
	18750		18750		162260
	12500		131250		811300
	6250		2006250		2433900
	2006250				1706163900

It is a matter of indifference which of the factors be used as the multiplier; for 4 multiplied by 3 gives the same product as 3 multiplied by 4; and the like holds universally true. To illustrate this, we may make three rows of points, four in each row, placing the . . . . rows under each other; and we shall have . . . . also four rows containing three points each, ... if we reckon the rows downwards.

Multiplication is proved by repeating the operation, using the multiplier for the multiplicand, and the multiplicand for the multiplier. It may also be proven by division, or by casting out the 9's, of which afterwards; and an account, wrought by any contraction, may be proven by performing the operation at large, or by a different contraction.

COMPOUND MULTIPLICATION.

RULE I.—*If the multiplier do not exceed* 12, *the operation is performed at once, beginning at the lowest place, and carrying according to the value of the place.*

EXAMPLES.

£	s.	d.	Cwt.	qr.	lb.	A.	R.	P.	Lb.	oz.	dwt.
13	6	7	12	2	8	13	3	18	7	5	9
		9			5			6			12
119	19	3	62	3	12	83	0	28	89	5	8

RULE II.—*If the multiplier be a composite number, whose component parts do not exceed* 12, *multiply first by one of these parts, then multiply the product by the other. Proceed in the same manner if there be more than two.*

Ex. 1*st.*	£15	3	8	by 32 = 8 × 4
			8	
	£121	9	4	= 8 times.
			4	
	£485	17	4	= 32 times.
2*d.*	£17	3	8	by 75 = 5 × 5 × 3
			3	
	£51	11	–	= 3 times.
			5	
	£257	15	–	= 15 times.
			5	
	£1288	15	–	= 75 times.

Note 1. Although the component parts will answer in any order, it is best, when it can be done, to take them in such order as may clear off some of the lower places at the first multiplication, as is done in *Ex.* 2*d.*

Note 2. The operation may be proved by taking the

Reduction. component parts in a different order, or dividing the multiplier in a different manner.

Rule III.—*If the multiplier be a prime number, multiply first by the composite number next lower, then by the difference, and add the products.*

£35	17	9	by 67 = 64+3	
		8	64 = 8×8	
£287	2	–	= 8 times.	
		8		
£2296	16	–	= 64 times.	
107	13	3	= 3 times.	
£2404	9	3	= 67 times.	

Here, because 8 times 8 is 64, we multiply twice by 8, which gives £2296. 16s. equal to 64 times the multiplicand: then we find the amount of 3 times the multiplicand, which is £107. 13s. 3d.; and it is evident that these added amount to 67, the multiplicand.

Rule IV.—*If there be a composite number a little above the multiplier, we may multiply by that number, and by the difference, and subtract the second product from the first.*

£17	4	5	by 106 = 108 — 2	
		12	108 = 9×12	
£206	13	–		
		9		
£1859	17	–	= 108 times.	
34	8	10	= 2 times.	
£1825	8	2	= 106 times.	

Here we multiply by 12 and 9, the component parts of 108, and obtain a product of £1859. 17s. equal to 108 times the multiplicand; and, as this is twice oftener than was required, we subtract the multiplicand doubled, and the remainder is the number sought.

Rule V.—*If the multiplier be large, multiply by* 10, *and multiply the product again by* 10; *by which means you obtain an hundred times the given number. If the multiplier exceed* 1000, *multiply by* 10 *again; and continue it farther if the multiplier require it; then multiply the given number by the unit-place of the multiplier; the first product by the ten-place, the second product by the hundred-place, and so on. Add the products thus obtained together.*

	£34	8	2½	by 5 =	£172	1	0½	=	5 times.
			10						
10 times	£344	2	1	by 6 =	2064	12	6	=	60 times.
			10						
100 times	£3441	–	10	by 4 =	13764	3	4	=	400 times.
			10						
1000 times	£34410	8	4	by 3 =	103231	5	–	=	3000 times.
					£119232	1	10½	=	3465 times.

The use of multiplication is to compute the amount of any number of equal articles, either in respect of measure, weight, value, or any other consideration. The multiplicand expresses how much is to be reckoned for each article, and the multiplier expresses how many times that is to be reckoned. As the multiplier points out the number of articles to be added, it is always an abstract number, and has no reference to any value or measure whatever. It is therefore quite improper to attempt the multiplication of shillings by shillings, or to consider the multiplier as expressive of any denomination.

Reduction.

Reduction is the computation for changing any sum of money, weight, or measure, into a different kind. When the quantity given is expressed in different denominations, we reduce the highest to the next lower, and add thereto the given number of that denomination; and proceed in like manner till we have reduced it to the lowest denomination.

Ex. To reduce £46. 13s. 8¾d. to farthings.

£46		
20		
920	shillings in £46	
13		
933	shillings in £46 13	
12		
11196	pence in £46 13	
8		
11204	pence in £46 13 8	
4		
44816	farthings in £46 13 8	
3		
44819	farthings in £46 13 8¾	

Or thus:

£46	13	8¾.	
20			
933			
12			
11204			
4			
44819			

It is easy to take in or add the higher denomination at the same time we multiply the lower.

Chap. V.—Division.

In division two numbers are given, and it is required to find how often the former contains the latter. Thus, it may be asked how often 21 contains 7, and the answer is exactly 3 times. The former given number (21) is called the *dividend*, the latter (7) the *divisor*, and the number required (3) the *quotient*. It frequently happens that the division cannot be completed exactly without fractions. Thus it may be asked, how often 8 is contained in 19? the answer is twice, and the remainder of 3.

This operation consists in subtracting the divisor from the dividend, and again from the remainder, as often as it can be done, and reckoning the number of subtractions; as,

21		19	
7	first subtraction	8	first subtraction
14		11	
7	second subtraction	8	second subtraction
7		3	remainder.
7	third subtraction.		
0			

As this operation, performed at large, would be very tedious when the quotient is a high number, it is proper to shorten it by every convenient method; and for this purpose we may multiply the divisor by any number whose product is not greater than the dividend, and so subtract it twice or thrice, or oftener, at the same time. The best way is to multiply it by the greatest number that does not raise the product too high, and that number is also the quotient. For example, to divide 45 by 7, we inquire what is the greatest multiplier for 7 that does not give a product above 45, and we shall find that it is 6; and 6 times 7 is 42, which, subtracted from 45, leaves a remainder of 3. Therefore 7 may be subtracted 6 times from 45; or, which is the same thing, 45 divided by 7, gives a quotient of 6 and a remainder of three.

If the divisor do not exceed 12, we readily find the highest multiplier that can be used from the multiplication table. If it exceed 12, we may try any multiplier that we think will answer. If the product be greater than the dividend, the multiplier is too great; and if the remainder, after the product is subtracted from the dividend, be greater than the divisor, the multiplier is too small. In either of these cases we must try another. But the attentive learner, after some practice, will generally hit on the right multiplier at first.

If the divisor be contained oftener than ten times in the dividend, the operation requires as many steps as

Division.

there are figures in the quotient. For instance, if the quotient be greater than 100, but less than 1000, it requires 3 steps. We first inquire how many hundred times the divisor is contained in the dividend, and subtract the amount of these hundreds. Then we inquire how often it is contained ten times in the remainder, and subtract the amount of these tens. Lastly, we inquire how many single times it is contained in the remainder. The method of proceeding will appear from the following example:

To divide 5936 by 8.

From	5936	
Take	5600 =	700 times 8.
Rem.	336	
From which take	320 =	40 times 8.
Rem.	16	
From which take	16 =	2 times 8.
	0	742 times 8 in all.

It is obvious, that as often as 8 is contained in 59, so many hundred times it will be contained in 5900, or in 5936; and as often as it is contained in 33, so many ten times it will be contained in 330, or in 336; and thus the higher places of the quotient will be obtained with equal ease as the lower. The operation might be performed by subtracting 8 continually from the dividend, which will lead to the same conclusion by a very tedious process. After 700 subtractions, the remainder would be 336; after 40 more it would be 16; and after 2 more the dividend would be entirely exhausted. In practice we omit the ciphers, and proceed by the following

Rules.—1. *Assume as many figures on the left hand of the multiplier as contain the divisor once or oftener; find how many times they contain it, and place the answer as the highest figure of the quotient.*

2. *Multiply the divisor by the figure you have found, and place the product under the part of the dividend from which it is obtained.*

3. *Subtract the product from the figures above it.*

4. *Bring down the next figure of the dividend to the remainder, and divide the number it makes up as before.*

Examples.] 1*st*, 8)5936(742 2*d*, 63)30114(478

```
        56··                252··
        ---                 ---
         33                  491
         32                  441
         --                  ---
          16                  504
          16                  504
          --                  ---
```

3*d*, 365)974932(2671$\frac{17}{365}$

```
        730···
        ------
        2449
        2190
        ----
         2593
         2555
         ----
           382
           365
           ---
Remainder   17
```

The numbers which we divide, as 59, 33, and 16, in the first example, are called *dividuals.*

It is usual to mark a point under the figures of the dividend as they are brought down, to prevent mistakes.

If there be a remainder, the division is completed by a vulgar fraction, whose numerator is the remainder, and its denominator the divisor. Thus, in Ex. 3 the quotient is 2671, and the remainder 17; and the quotient completed is 2671 $\frac{17}{365}$.

A number which divides another without a remainder is said to measure it; and the several numbers which measure another are called its *aliquot parts.* Thus 2, 4, 6, 8, and 12, are aliquot parts of 24. As it is often useful to discover numbers which measure others, we may observe,

1*st*, Every number ending with an even figure, that is, with 2, 4, 6, 8, or 0, is measured by 2.

2*dly*, Every number ending with 5 or 0 is measured by 5.

3*dly*, Every number whose figures, when added, amount to an even number of 3's or 9's, is measured by 3 or 9, respectively.

Contractions and Varieties in Division.

1*st*, When the divisor does not exceed 12, the whole computation may be performed without setting down any figures except the quotient.

Ex. 7)35868(5124 or 7)35868
5124

2*dly*, When the divisor is a composite number, and one of the component parts also measures the dividend, we may divide successively by the component parts.

Ex. 1*st*,] 30114 by 63 2*d*,] 975 by 105=5×7×3

```
        9)30114                5)975
        7) 3346                3)195
Quotient    478                7) 65
                        Quotient  9 2/7
```

This method might be also used although the component parts of the divisor do not measure the dividend; but the management of the remainder requires the doctrine of vulgar fractions.

3*dly*, When there are ciphers annexed to the divisor, cut them off, and cut off an equal number of figures from the dividend; annex those figures to the remainder.

Ex. To divide 378643 by 5200.

```
52|00)3786|43(72 4243/5200.
      364·
      ---
       146
       104
       ---
        4243
```

The reason will appear by performing the operation at large, and comparing the steps.

To divide by 10, 100, 1000, or the like: Cut off as many figures on the right hand of the dividend as there are ciphers in the divisor. The figures which remain on the left hand compose the quotient, and the figures cut off compose the remainder.

Note.—Since 4 times 25 make 100, instead of dividing by 25, we may multiply the dividend by 4, and cut off the two last figures from the product. The figures left will be the quotient, and those cut off the remainder. In like manner, to divide by 125, which multiplied by 8 produces 1000, we may multiply the dividend by 8, and cut off three figures, which will be the remainder, and those left the quotient.

4*thly*, When the divisor consists of several figures, we may try them separately, by inquiring how often the first figure of the divisor is contained in the first figure of the dividend, and then considering whether the second and following figures of the divisor be contained as often in the corresponding ones of the dividend with the remainder (if any) prefixed. If not, we must begin again, and make trial of a lower number. When the remainder is nine or upwards, we may be sure the division will hold through the lower places; and it is unnecessary to continue the trial farther.

5*thly*, We may make a table of the products of the divisor, multiplied by the nine digits, in order to discover more readily how often it is contained in each dividual. This is convenient when the dividend is very long, or when it is required to divide frequently by the same divisor

```
73 by 2 = 146        73)53872694(737982
      3 = 219           511·····
      4 = 292            277
      5 = 365            219
      6 = 438             582
      7 = 511             511
      8 = 584              716
      9 = 657              657
                            599
                            584
                             154
                             146
                      Rem.    8
```

6thly, To divide by 9, 99, 999, or any number of 9's, transcribe under the dividend part of the same, shifting the highest figure as many places to the right hand as there are 9's in the divisor. Transcribe it again, with the like change of place, as often as the length of the dividend admits; add these together, and cut off as many figures from the right hand of the sum as there are 9's in the divisor. The figures which remain on the left hand compose the quotient, and those cut off the remainder.

If there be any carriage to the unit place of the quotient, add the number carried likewise to the remainder, as in Ex. 2; and if the figures cut off be all 9's, add 1 to the quotient, and there is no remainder.

```
Ex. 1st,  99)324123          2d,  99)547825
             3241                     5478
               32                       54
           3273|96                  5533|57
Quotient   3273 and rem. 96.              1
                                Quotient 5533·58 rem.

3d,  999)476523
            476
         476|999
            1
Quotient  477
```

To explain the reason of this, we must recollect, that whatever number of hundreds any dividend contains, it contains an equal number of 99's, together with an equal number of units. In Ex. 1, the dividend contains 3241 hundreds, and a remainder of 23. It therefore contains 3241 times 99, and also 3241, besides the remainder already mentioned.—Again, 3241 contains 32 hundreds and a remainder of 41. It therefore contains 32 99's, and also 32, besides the remainder of 41. Consequently the dividend contains 99, altogether, 3241 times and 32 times, that is, 3273 times, and the remainder consists of 23, 41, and 32, added, which make 96.

As multiplication supplies the place of frequent additions, and division of frequent subtractions, they are only repetitions and contractions of the simple rules; and, when compared together, their tendency is exactly opposite. As numbers, increased by addition, are diminished and brought back to their original quantity by subtraction; in like manner numbers compounded by multiplication are reduced by division to the parts from which they were compounded. The multiplier shows how many additions are necessary to produce the number; and the quotient shows how many subtractions are necessary to exhaust it. It follows that the product, divided by the multiplicand, will quote the multiplier; and because either factor may be assumed for the multiplicand, therefore the product divided by either factor quotes the other. It follows, also, that the dividend is equal to the product of the divisor and quotient multiplied together; and hence these operations mutually prove each other.

To prove multiplication: Divide the product by either factor. If the operation be right, the quotient is the other factor, and there is no remainder.

To prove division: Multiply the divisor and quotient together; to the product add the remainder, if any; and, if the operation be right, it makes up the dividend. Otherwise divide the dividend (after subtracting the remainder, if any) by the quotient. If the operation be right, it will quote the divisor. The reason of all those rules may be collected from the last paragraph.

Compound Division.

Rule I.—*When the dividend only consists of different denominations, divide the higher denomination, and reduce the remainder to the next lower, taking in* (p. 547, Reduction) *the given number of that denomination, and continue the division.*

Examples.

Divide £465. 12s. 8d. by 72.

```
   £   s.  d.   £  s.  d.
72)465  12  8  (6  9  4
   432  · · ·
    33
    20
72)672
   648
    24
    12
72)296
   288
     8 Rem.
```

Or we might divide by the component parts of 72 as explained under (*2dly*, p. 548).

Divide 345 cwt. 1 qr. 8 lb. by 22.

```
   Cwt. q. lb.   Cwt. q. lb.
22)345  1  8  (15  2  22
   22·  · ·
   125
   110
    15
     4
22)61
   44
    17
    28
   144
    34
22)484
   44
    44
    44
```

Rule II.—*When the divisor is in different denominations, reduce both divisor and dividend to the lowest denomination, and proceed as in simple division. The quotient is an abstract number.*

To divide £38. 13s. by £3. 4s. 5d.

```
£3  4  5     £38 13
20            20
64            773
12            12
773          )9276(12 quot.
              773
              1546
              1546
```

To divide 96 cwt. 1 qr. 20 lb. by 3 cwt. 2 qr. 8 lb.

```
Cwt. q. lb.   Cwt. q. lb.
 3  2  8 )  96  1  20
 4            4
14           385
28            28
120          3100
28           770
4|00        )108|00(27 quot.
```

It is best not to reduce the terms lower than is necessary to render them equal. For instance, if each of them consists of an even number of sixpences, fourpences, or the like, we reduce them to sixpences or fourpences, but not to pence.

The use of division is to find either of the factors by whose multiplication a given number is produced when the other factor is given, and therefore is of two kinds, since either the multiplier or the multiplicand may be

Division. given. If the former be given, it discovers what that number is which is contained so many times in another. If the latter be given, it discovers how many times one number is contained in another. Thus, it answers the questions of an opposite kind to those mentioned under Rule IV. p. 547, as, to find the quantity of a single parcel or share; to find the value, weight, or measure, of a single article; to find how much work is done, provisions consumed, interest incurred, or the like, in a single day, &c.

The last use of division is a kind of reduction exactly opposite to that described under Rule V. p. 547. The manner of conducting and arranging it, when there are several denominations in the question, will appear from the following examples.

1 To reduce 15783 pence to pounds, shillings, and pence.

```
          20
12)15783(1315(65
   12···  120·
   ----   ----
    37     115
    36     100
   ----   ----
     18     15
     12
    ---
      63
      60
     ---
       3
```

Answer, £65. 15s. 3d.

2. To reduce 174865 grs. to lbs. oz. and dwt. Troy.

```
            20    12
24)174865(7286(364(30
   168···  60··  36·
   ----   ----  ----
     68    128    04
     48    120
    ---   ----
    206     86
    192     80
    ---    ---
     145     6
     144
     ---
       1
```

Ans. 30 lb. 4 oz. 6 dwt. 1 gr.

In the first example we reduce 15783 pence to shillings, by dividing by 12, and obtain 1315 shillings, and a remainder of 3 pence. Then we reduce 1315 shillings to pounds by dividing by 20, and obtain 65 pounds and a remainder of 15 shillings. The divisions might have been contracted.

In the practice of arithmetic questions often occur which require both multiplication and division to resolve. This happens in reduction, when the higher denomination does not contain an exact number of the lower.

Rule for Mixed Reduction.—*Reduce the given denomination by multiplication to some lower one which is an aliquot part of both; then reduce that by division to the denomination required.*

Ex.—Reduce £31742 to guineas.

```
   31742
      20
  ------
21)634840(30230
   63····
   ------
    048
     42
    ---
     64
     63
    ---
     10
```

Here we multiply by 20, which reduces the pounds to shillings, and divide the product by 21, which reduces the shillings to guineas.

Answer, 30230 guineas and 10 shillings.

Note 1. Guineas may be reduced to pounds by adding one twentieth part of the number.

2. Pounds may be reduced to merks by adding one half.

3. Merks may be reduced to pounds by subtracting one third.

Another case which requires both multiplication and division is, when the value, weight, measure, or duration of any quantity is given, and the value, &c. of a different quantity required, we first find the value, &c. of a single article by division, and then the value, &c. of the quantity required, by multiplication.

Ex. If 3 yards cost 15s. 9d. what will 7 yards cost at the same rate?

```
      s.  d.
3)   15   9 price of 3 yards.
      5   3 price of 1 yard, by Rule IV. p. 547.
          7
  ---------
  £1 16   9 price of 7 yards (by par. ult. p. 549, col. 2.)
```

Many other instances might be adduced where the operation and the reasons of it are equally obvious. These are generally, though unnecessarily, referred to the rule of proportion.

We shall now offer a general observation on all the operations in arithmetic. When a computation requires several steps, we obtain a just answer, whatever order we follow. Some arrangements may be preferable to others in point of ease, but all of them lead to the same conclusion. In addition or subtraction we may take the articles in any order, as is evident from the idea of number; or we may collect them into several sums, and add or subtract these either separately or together. When both the simple operations are required to be repeated, we may either complete one of them first, or may introduce them promiscuously; and the compound operations admit of the same variety. When several numbers are to be multiplied together, we may take the factors in any order, or we may arrange them into several classes, find the product of each class, and then multiply the products together. When a number is to be divided by several others we may take the divisors in any order, or we may multiply them into each other, and divide by the product; or we may multiply them into several parcels, and divide by the products successively. Lastly, When multiplication and division are both required, we may begin with either; and when both are repeatedly necessary, we may collect the multipliers into one product and the divisors into another, or we may collect them into parcels, or use them singly, and that in any order. Still we shall obtain the proper answer if none of the terms be neglected.

When both multiplication and division are necessary to obtain the answer of a question, it is generally best to begin with the multiplication, as this order keeps the account as clear as possible from fractions. The example last given may be wrought accordingly as follows:

```
      s.  d.
      15   9
           7
  ---------
3)5  10   3
  1  16   9
```

Some accountants prove the operations of arithmetic by a method which they call casting out the 9's, depending on the following principles:

1*st*, If several numbers be divided by any divisor (the remainders being always added to the next number), the sum of the quotients, and the last remainder, will be the same as those obtained when the sum of the number is divided by the same divisor. Thus, 19, 15, and 23, contain together as many 5's, as many 7's, &c. as their sum 57 does, and the remainders are the same; and, in this way, addition may be proven by division. It is from the correspondence of the remainders that the proof by casting out the 9's is deduced.

2*dly*, If any figure with ciphers annexed be divided by 9, the quotient consists entirely of that figure; and the remainder is also the same. Thus, 40 divided by 9 quotes 4, remainder 4; and 400 divided by 9 quotes 44, remainder 4. The same holds with all the digits, and the reason will be easily understood: every digit, with a ci-

Division. pher annexed, contains exactly so many tens; it must therefore contain an equal number of 9's, besides a remainder of an equal number of units.

3dly, If any number be divided by 9, the remainder is equal to the sum of the figures of the number, or to the remainder obtained, when that sum is divided by 9. For instance, 3765 divided by 9 leaves a remainder of 3; and the sum of 3, 7, 6, and 5, is 21, which divided by 9 leaves a remainder of 3. The reason of this will appear from the following illustration:

3000	divided by 9 quotes	333,	remainder 3
700	9 quotes	77,	remainder 7
60	9 quotes	6,	remainder 6
5	9 quotes	0,	remainder 5
3765		416,	sum of rem. 21

Again: 21 divided by 9 quotes 2, remainder 3; wherefore, 3765 divided by 9 quotes 418, remainder 3; for the reason given. Hence we may collect the following rules for practice:

To cast the 9's out of any number, or to find what remainder will be left when any number is divided by 9: add the figures; and when the sum exceeds 9, add the figures which would express it. Pass by the 9's; and when the sum comes exactly to 9, neglect it, and begin anew. For example, if it be required to cast the 9's out of 3573294, we reckon thus; 3 and 5 are 8, and 7 is 15; 1 and 5 are 6, and 3 is 9, which we neglect; 2 and (passing by 9) 4 are 6; which is the remainder or Result. If the article out of which the 9's are to be cast contains more denominations than one, we cast the 9's out of the higher, and multiply the result by the value of the lower, and carry on the product (casting out the 9's, if necessary) to the lower.

To prove addition, cast the 9's out of the several articles, carrying the results to the following articles; cast them also out of the sum. If the operation be right, the results will agree.

To prove subtraction, cast the 9's out of the minuend; cast them also out of the subtrahend and remainder together; and if you obtain the same result, the operation is presumed right.

To prove multiplication, cast the 9's out of the multiplicand, and also out of the multiplier if above 9. Multiply the results together, and cast the 9's, if necessary, out of their product. Then cast the 9's out of the product, and observe if this result correspond with the former.

Ex. 1*st*, 9276 res. 6 × 8 = 48 res. 3.
8
74208 res. 3.

2*d*, 7898 res. 5 × 3 = 15 res. 6.
48 res. 3
63184
31592
379104 res. 6.

The reason of this will be evident, if we consider multiplication under the view of repeated addition. In the first example it is obviously the same. In the second, we may suppose the multiplicand repeated 48 times. If this be done, and the 9's cast out, the result, at the end of the 9th line, will be 0; for any number, repeated 9 times, and divided by 9, leaves no remainder. The same must happen at the end of the 18th, 27th, 36th, and 45th lines; and the last result will be the same as if the multiplicand had only been repeated 3 times. This is the reason for casting out the 9's from the multiplier as well as the multiplicand.

To prove division, cast the 9's out of the divisor, and also out of the quotient; multiply the results, and cast the 9's out of the product. If there be any remainder, add to it the result, casting out the 9's if necessary. If the account be right, the last result will agree with that obtained from the dividend.

Simple Proportion.

Ex. 42) 2490 (59 res. 5 × 6 = 30 res. 3.
res. 6. 210
390
378
Rem. 12 - - - res. 3.
6

And the result of the dividend is 6.

This depends on the same reason as the last; for the dividend is equal to the product of the divisor, and quotient added to the remainder.

We cannot recommend this method, as it lies under the following disadvantages.

1*st*, If an error of 9, or any of its multiples, be committed, the results will nevertheless agree; and so the error will remain undiscovered. And this will always be the case when a figure is placed or reckoned in a wrong column, which is one of the most frequent causes of error.

2*dly*, When it appears by the disagreement of the results that an error has been committed, the particular figure or figures in which the error lies are not pointed out, and consequently it is not easily corrected.

Chap. VI.—Rule of Proportion.

Sect. I.—Simple Proportion.

Quantities are reckoned proportional to each other when they are connected in such a manner, that if one of them be increased or diminished, the other increases or diminishes at the same time, and the degree of the alteration on each is a like part of its original measure. Thus, four numbers are in the same proportion, the first to the second as the third to the fourth, when the first contains the second, or any part of it, as often as the third contains the fourth, or the like part of it. In either of these cases, the quotient of the first divided by the second is equal to that of the third divided by the fourth; and this quotient may be called the *measure of the proportion.*

Proportionals are marked down in the following manner:

6 : 3 :: 8 : 4
12 : 36 :: 9 : 27
9 : 6 :: 24 : 16
16 : 24 :: 10 : 15

The rule of Proportion directs us, when three numbers are given, how to find a fourth, to which the third may have the same proportion that the first has to the second. It is sometimes called the *Rule of Three*, from the three numbers given; and sometimes the *Golden Rule*, from its various and extensive utility.

Rule. *Multiply the second and third terms together, and divide the product by the first.*

Ex. To find a fourth proportional to 18, 27, and 34.

18 : 27 :: 34 : 51
34
108
81
18)918(51
90
18
18

To explain the reason of this, we must observe, that if

Simple Proportion.

two or more numbers be multiplied or divided alike, the products or quotients will have the same proportion.

18 : 27
Multiplied by 34, 612 : 918
Divided by 18, 34 : 51

The products 612, 918, and the quotients 34, 51, have therefore the same proportion to each other that 18 has to 27. In the course of this operation, the products of the first and third terms are divided by the first; therefore the quotient is equal to the third.

The first and second terms must always be of the same kind; that is, either both moneys, weights, measures, both abstract numbers, or the like. The fourth, or number sought, is of the same kind as the third.

When any of the terms is in more denominations than one, we may reduce them all to the lowest. But this is not always necessary. The first and second should not be reduced lower than directed, p. 549, col. 2, par. penult.; and when either the second or third is a simple number, the other, though in different denominations, may be multiplied without reduction.

```
                £   s.  d.
Ex. 5 : 7 :: 25  11   3
                              7
 ------------------------------
        5) 178  18   9     (35  15  9
```

The accountant must consider the nature of every question, and observe the circumstance which the proportion depends on; and common sense will direct him to this if the terms of the question be understood. It is evident that the value, weight, and measure of any commodity is proportioned to its quantity; that the amount of work or consumption is proportioned to the time; that gain, loss, or interest, when the rate and time are fixed, is proportioned to the capital sum from which it arises; and that the effect produced by any cause is proportioned to the extent of the cause. In these and many other cases the proportion is direct, and the number sought increases or diminishes along with the term from which it is derived.

In some questions, the number sought becomes less when the circumstances from which it is derived become greater. Thus, when the price of goods increases, the quantity which may be bought for a given sum is smaller; when the number of men employed at work is increased, the time in which they may complete it becomes shorter; and when the activity of any cause is increased, the quantity necessary to produce a given effect is diminished. In these and the like the proportion is said to be inverse.

General Rule for stating all questions, whether direct or inverse. *Place that number for the third term which signifies the same kind of thing with what is sought, and consider whether the number sought will be greater or less. If greater, place the least of the other terms for the first; but if less, place the greatest for the first.*

Ex. 1*st*, If 30 horses plough 12 acres, how many will 42 plough in the same time?

H. H. A
30 :: 42 :: 12 : answer.

Here, because the thing sought is a number of acres, the place 12, the given number of acres, for the third term; and because 42 horses will plough more than 30, we make the lesser number, 30, the first term, and the greater number, 42, the second term.

Ex. 2*d*, If 40 horses be maintained for a certain sum on hay, at 5d. per stone, how many will be maintained on the same sum when the price of hay rises to 8d.

d. d. H.
8 : 5 :: 40 : answer.

Here, because a number of horses is sought, we make the given number of horses, 40, the third term; and because fewer will be maintained for the same money when the price of hay is dearer, we make the greater price, 8d. the first term, and the lesser price, 5d. the second term.

Compound Proportion.

The first of these examples is direct, the second inverse. Every question consists of a supposition and demand. In the first, the supposition is, that 30 *horses plough* 12 *acres*, and the demand, *how many* 42 *will plough;* and the first term of the proportion, 30, is found in the supposition, in this and every other direct question. In the second, the supposition is, that 40 *horses are maintained on hay at* 5d., and the demand, *how many will be maintained on hay at* 8d.? and the first term of the proportion, 8, is found in the demand, in this and every other inverse question.

When a proportion is stated, if the first and second terms, or first and third, be measured by the same number, we may divide them by that measure, and use the quotients in their stead.

Ex. If 36 yards cost 42 shillings, what will 27 cost?

```
 Y.  Y.  sh.
36 : 27 :: 42          Here 36 and 27 are both
 4 :  3 :: 42          measured by 9, and we work
              3        with the quotients 4 and 3.
            ----  s.  d.
        4)126(31  6, the answer.
```

SECT. II.—COMPOUND PROPORTION.

Sometimes the proportion depends upon several circumstances. Thus, it may be asked, if 18 men consume 6 bolls of corn in 28 days, how much will 24 men consume in 56 days? Here the quantity required depends partly on the number of men, partly on the time; and the question may be resolved into the two following ones:

1*st*, If 18 men consume 6 bolls in a certain time, how many will 24 men consume in the same time?

```
M.  M.  B.  B.
18 : 24 : 6 : 8        Answer, 24 men will consume 8
      6                bolls in the same time.
    ----
18) 144(8
```

2*d*, If a certain number of men consume 8 bolls in 28 days, how many will they consume in 56 days?

```
D.  D.  B.  B.
28 : 56 :: 8 : 16      Ans. The same number of men
      8                will consume 16 bolls in 56 days.
    ----
28) 448(16
```

In the course of this operation, the original number of bolls, 6, is first multiplied into 24, then divided by 18, then multiplied into 56, then divided by 28. It would answer the same purpose to collect the multipliers into one product and the divisors into another, and then to multiply the given number of bolls by the former, and divide the product by the latter, p. 550, col. 2.

The above question may therefore be stated and wrought as follows:

```
Men 18 : 24 :: 6 bolls     Here we multiply 18 into
Days 28 : 56               28 for a divisor, and 6 into
    ----  ----             the product of 24 by 56 for
    144   144              a dividend.
    36    120
    ----  ----
    504   1344
            6
          ----
   504)8064(16, answer.
```

In general, state the several particulars on which the question depends, as so many simple proportions, attending to the sense of the question to discover whether the proportions should be stated directly or inversely; then multiply all the terms in the first rank together, and all

Distributive Proportion.

those in the second rank together, and work with the product as directed in the simple rule (Sect. i. p. 551.)

Ex. If 100 men make 3 miles of road in 27 days, in how many days will 150 men make 5 miles?

Men 150 : 100 :: 27 days.

```
  3   5
 450 500
      27
 450)13500(30 days, ans.
```

Here the first stating is inverse, because more men will do it in fewer days; but the second is direct, because more miles will require more days.

The following contraction is often useful. After stating the proportion, if the same number occurs in both ranks, dash it out from both; or, if any term in the first rank and another in the second rank are measured by the same numbers, dash out the original terms, and use the quotients in their stead.

Ex. If 18 men consume £30 value of corn in 9 months when the price is 16s. per boll, how many will consume £54 value in 6 months when the price is 12s. per boll? In this question the proportion depends upon three particulars—the value of corn, the time, and price; the first of which is direct, because the greater the value of provisions is, the more time is required to consume them; but the second and third are inverse, for the greater the time and price are, fewer men will consume an equal value.

Value ~~30~~ : ~~54~~ :: 18 men.

```
Months ~~6~~ : ~~9~~
Price  ~~12~~ : ~~16~~
       10   9
        ~~3~~  ~~3~~
            4
       36
       18
      288
       36
      10)648(64 3/10
```

Here we observe 6 in the first rank measures 54 in the second; so we dash them out, and place the quotient 9 in the second rank. Next, because 30 and 9 are both measured by 3, we dash them out, and place down the quotients 10 and 3; then, because 12 and 16 are both measured by 4, we dash them out and place down the quotients 3 and 4. Lastly, because there is now 3 in both columns, we dash them out, and work with the remaining terms, according to the rule.

The moneys, weights, and measures of different countries may be reduced from the proportion which they bear to each other.

Ex. If 112 lb. avoirdupois make 104 lb. of Holland, and 100 lb. of Holland make 89 of Geneva, and 110 of Geneva make 117 of Seville, how many lbs. of Seville will make 100lb. avoirdupois?

112 : 104 :: 100
100 : 89
110 : 117

If it be required how many lb. avoirdupois will make 100 of Seville, then the terms must be placed in the different columns thus,—

104 : 112 :: 100
89 : 100
117 : 110

SECT. III.—DISTRIBUTIVE PROPORTION.

If it be required to divide a number into parts which have the same proportion to each other that several other given numbers have, we add these numbers together, and state the following proportion: As the sum is to the particular numbers, so is the number required to be divided to the several parts sought.

Ex. 1. Four partners engage to trade in company; A's stock is £150, B's £320, C's £350, D's £500, and they gain £730: Required how much belongs to each if the gain be divided among them in proportion to their stocks?

						Rem.	Practice.
A's stock	£150	1320 : 150 :: 730 :	£ 82	19	1	—120	
B's	320	1320 : 320 :: 730 :	176	19	4	—960	
C's	350	1320 : 350 :: 730 :	193	11	2	—720	
D's	500	1320 : 500 :: 730 :	276	10	3	—840	
Whole stock	£1320		Proof £730				

This account is proved by adding the gains of the partners, the sum of which will be equal to the whole gain if the operation be right; but if there be remainders, they must be added, their sum divided by the common divisor, and the quotient carried to the lowest place.

Ex. 2. A bankrupt owes A £146, B £170, C £45, D £480, and E £72; his whole effects are only £342. 7s. 6d. How much should each have?

A's debt	£146	913 : 146 ::	£342 7 6 :	£ 54	15	A's share.
B's	170	913 : 170 ::	342 7 6 :	63	15	B's
C's	45	913 : 45 ::	342 7 6 :	16	17 6	C's
D's	480	913 : 480 ::	342 7 6 :	180		D's
E's	72	913 : 72 ::	342 7 6 :	27		E's
	£913			£342	7 6	

This might also be calculated by finding what composition the bankrupt was able to pay per pound, which is obtained by dividing the amount of his effects by the amount of his debts, and comes to 7s. 6d., and then finding by the rules of practice how much each debt came to at that rate.

CHAP. VII.—RULES FOR PRACTICE.

The operations explained in the foregoing chapters comprehend the whole system of arithmetic, and are sufficient for every computation. In many cases, however, the work may be contracted by adverting to the particular circumstances of the question. We shall explain in this chapter the most useful methods which practice has suggested for rendering mercantile computations easy, in which the four elementary rules of arithmetic are sometimes jointly, sometimes separately employed.

SECT. I.—COMPUTATION OF PRICES.

The value of any number of articles, at a pound, a shilling, or a penny, is an equal number of pounds, shillings, or pence; and these two last are easily reduced to pounds. The value at any other rate may be calculated by easy methods, depending on some contraction already explained, or on one or more of the following principles.

1*st*, If the rate be an aliquot part of a pound, a shilling, or a penny, then an exact number of articles may be bought for a pound, a shilling, or a penny; and the value is found by dividing the given number accordingly. Thus, to find the price of so many yards at 2s. 6d., which is the eighth part of a pound, we divide the quantity by eight, because every eight yards cost £1.

2*d*, If the rate be equal to the sum of two other rates which are easily calculated, the value may be found by computing these separately, and adding the sums obtained. Thus, the price of so many yards at 9d. is found by adding their prices at 6d. and 3d. together.

3*d*, If the rate be equal to the difference of two easy rates, they may be calculated separately, and the lesser subtracted from the greater. Thus, the value of so many articles at 11d. is found by subtracting their value at a penny from their value at a shilling. We may suppose that a shilling was paid for each article, and then a penny returned on each.

4*th*, If the rate be a composite number, the value may be found by calculating what it comes to at one of the component parts, and multiplying the same by the other.

CASE I. *When the rate is an aliquot part of a pound, divide the quantity by the number which may be bought for a pound.*

Table of the aliquot parts of £1.

10 shillings	$= \frac{1}{2}$ of £1.	1s. 4d.	$= \frac{1}{15}$ of £1.
6s. 8d.	$= \frac{1}{3}$	1s. 3d.	$= \frac{1}{16}$
5s.	$= \frac{1}{4}$	1s.	$= \frac{1}{20}$
4s.	$= \frac{1}{5}$	8d.	$= \frac{1}{30}$
3s. 4d.	$= \frac{1}{6}$	6d.	$= \frac{1}{40}$
2s. 6d.	$= \frac{1}{8}$	4d.	$= \frac{1}{60}$
2s.	$= \frac{1}{10}$	3d.	$= \frac{1}{80}$
1s. 8d.	$= \frac{1}{12}$	2d.	$= \frac{1}{120}$

Ex. 1*st*,] What is the value of 7463 yards, at 4s.?

5)7463
£1492. 12s.

2*d*,] What is the value of 1773 yards, at 3d.?

80)1773
£22. 3s. 3d.

In the first example we divide by 5 because 4s. is $\frac{1}{5}$ of a pound; the quotient 1492 shows how many pounds they amount to; besides which there remain three yards at 4s., and these come to 12s. In the second example we divide by 80, as directed, and the quotient gives £22, and the remainder 13 yards, which at 3d. come to 3s. 3d.

This method can only be used in calculating for the particular prices specified in the table. The following six cases comprehend all possible rates, and will therefore exhibit different methods of solving the foregoing questions.

Case II. *When the rate consists of shillings only, multiply the quantity by the number of shillings, and divide the product by* 20: *Or, if the number of shillings be even, multiply by half the number, and divide the product by* 10.

Ex. 1*st*,] 4573 at 13s.

13
13719
4573
20)59449
£2972. 9s.

2*d*,] 7543 at 14s.

7
10)52801
£5280. 2s.

It is easy to perceive that the method in which the second example is wrought must give the same answer as if the quantity had been multiplied by 14 and divided by 20; and as the division by 10 doubles the last figure for shillings, and continues all the rest unchanged for pounds, we may obtain the answer at once, by doubling the right-hand figure of the product before we set it down.

If the rate be the sum of two or more aliquot parts of a pound, we may calculate these as directed in Case I. and add them. If it be any odd number of shillings, we may calculate for the even number next lower, and add thereto the value of a shilling. If it be 19s. we may subtract the value at a shilling from the value at a pound.

Case III. *When the rate consists of pence only.*

Method 1. If the rate be an aliquot part of a shilling, divide the quantity accordingly, which gives the answer in shillings; if not, it may be divided into two or more aliquot parts: calculate these separately, and add the values; reduce the answer to pounds.

1 penny is $\frac{1}{12}$ of a shilling.
2d. $\frac{1}{6}$ of ditto.
3d. $\frac{1}{4}$ of ditto.
4d. $\frac{1}{3}$ of ditto.
6d. $\frac{1}{2}$ of ditto.
5d. is the sum of 4d. and 1d. or of 2d. and 3d.
7d. is the sum of 4d. and 3d. or of 6d. and 1d.
8d. is the sum of 6d. and 2d. or the double of 4d.
9d. is the sum of 6d. and 3d.
10d. is the sum of 6d. and 4d.
11d. is the sum of 6d. 3d. and 2d.

Ex. 1*st*,] 7423 at 4d.

3)7423
20)2474 4
£123 14 4

Here, because 4d. is one third of a shilling, we divide by 3, which gives the price in shillings, and reduce these by division to pounds.

Ex. 2*d*,] 9786 at 9d.

At 6d. $= \frac{1}{2}$ of 1s. 4893
At 3d. $= \frac{1}{2}$ of 6d. 2446 6
At 9d. 7339 6
£366 19 6

Ex. 3*d*,] 4856 at 11d.

At 6d. $= \frac{1}{2}$ of 1s. 2428
At 3d. $= \frac{1}{2}$ of 6d. 1214
At 2d. $= \frac{1}{3}$ of 6d. 809 4
11d. 4451 4
£222 11 4

Here we suppose first 6d. and then 3d. to be paid for each article; half the quantity is the number of shillings they would cost at 6d. each, half of that is the cost at 3d., and these added and reduced give the answer.

Here we calculate what the articles would cost at 6d., at 3d., and at 2d., and add the values.

It is sometimes easier to calculate at two rates whose difference is the rate required, and subtract the lesser value from the greater. Thus, the last example may be wrought by subtracting the value at a penny from the value at a shilling. The remainder must be the value at 11d.

At 1s. 4856s.
At 1d. $= \frac{1}{12}$ 404 8
At 11d. 4451 4
£222 11 4

10d. may be wrought as the difference of 1s. and 2d.; and several other rates in like manner.

Method 2. Multiply the quantity by the number of pence, the product is the answer in pence. Reduce it to pounds.

Method 3. Find the value at a penny by division, and multiply the same by the number of pence.

Case IV. *When the rate consists of farthings only, find the value in pence, and reduce it by division to pounds.*

Ex. 1*st*,] 37843 at 1 farthing.

4)37843 farth.
12) 9460$\frac{3}{4}$ pence
788 4$\frac{3}{4}$
£39 8 4$\frac{3}{4}$

2*d*,] 23754 at $\frac{1}{2}$d.

2) 23754 halfpence
12) 11877 pence
989 9
£49 9 9

3*d*, 72564 at $\frac{3}{4}$
3
4)217692 farth.
12) 54423 pence
4535 3
£226 15 3

Or, 72564
At $\frac{1}{2}$d. 36282 d.
At $\frac{1}{4}$d. 18141 d.
12) 54423
4535 3
£226 15 3

We may also find the amount in twopences, threepences, fourpences, or sixpences, by one division, and reduce these as directed in Case I.

Case V. *When the rate consists of pence and farthings, find the value of the pence, as directed in Case III., and that of the farthings from the proportion which they bear to the pounds. Add these together, and reduce.*

Ex. 1*st*,] 3287 at 5$\frac{1}{4}$d.

At 4d. $= \frac{1}{3}$ of 1s. 1095 8
At 1d. $= \frac{1}{4}$ of 4d. 273 11
At 1f. $= \frac{1}{4}$ of 1d. 68 5$\frac{3}{4}$
At 5$\frac{1}{4}$ 1438 0$\frac{3}{4}$
£71 18 0$\frac{3}{4}$

Ex. 2*d*,] 4573 at 2$\frac{3}{4}$

At 2d. $= \frac{1}{6}$ of 1s. 762 2
At $\frac{1}{2}$d. $= \frac{1}{4}$ of 2d. 190 6$\frac{1}{2}$
At $\frac{1}{4}$d. $= \frac{1}{2}$ of $\frac{1}{2}$d. 95 3$\frac{1}{4}$
At 2$\frac{3}{4}$ 1047 11$\frac{3}{4}$
£52 7 11$\frac{3}{4}$

Ex. 3*d*,] 2842 at 3$\frac{3}{4}$

At 3d. $= \frac{1}{4}$ of 1s. 710 6
At 3f. $= \frac{1}{4}$ of 3d. 177 7$\frac{1}{2}$
At 3$\frac{3}{4}$ 888 1$\frac{1}{2}$
£44 8 1$\frac{1}{2}$

Ex. 4*th*,] 3572 at 7$\frac{1}{2}$

At 6d. $= \frac{1}{2}$ of 1s. 1786
At 1$\frac{1}{2}$d. $= \frac{1}{4}$ of 6d. 446 6
At 7$\frac{1}{2}$ 2232 6
£111 12 6

Practice. It is sometimes best to join some of the pence with the farthings in the calculation. Thus, in Ex. 4. we reckon the value at 6d. and at 3 halfpence, which makes $7\frac{1}{2}$.

If the rate be $1\frac{1}{2}$, which is an eighth part of a shilling, the value is found in shillings by dividing the quantity by 8.

CASE VI. *When the rate consists of shillings and lower denominations.*

Method 1. Multiply the quantity by the shillings, and find the value of the pence and farthings, if any, from the proportion they bear to the shillings. Add and reduce.

Ex. 1*st*, 4258 at 17s. 3d.

		17
		29806
		4258
17s.		72386
3d.	$=\frac{1}{4}$ of 1s.	1064 6
17s. 3d.		73450 6
		£3672 10 6

Ex. 2*d*, 5482 at 12s. $4\frac{1}{2}$d.

		12
12s.		65784
3d.	$=\frac{1}{4}$ of 1s.	1370 6
$1\frac{1}{2}$d.	$=\frac{1}{2}$ of 3d.	685 3
12s. $4\frac{1}{2}$d.		67839 9
		£3391 19 9

Method 2. Divide the rate into aliquot parts of a pound; calculate the values corresponding to these, as directed in Case I., and add them.

Ex. 1*st*, 3894 at 17s. 6d.

10s.	$=\frac{1}{2}$	£1947
5s.	$=\frac{1}{4}$	973 10
2s. 6d.	$=\frac{1}{8}$	486 15
17s. 6d.		£3407 5

Ex. 2*d*, 1765 at 9s. 2d.

6s. 8d.	$=\frac{1}{3}$	£588 6 8
2s. 6d.	$=\frac{1}{8}$	220 12 6
9s. 2d.		£808 19 2

Sometimes part of the value is more readily obtained from a part already found; and sometimes it is easiest to calculate at a higher rate, and subtract the value at the difference.

Ex. 3*d*, 63790 at 5s. 4d.

4s.	$=\frac{1}{5}$	£12758
1s. 4d.	$=\frac{1}{3}$ of 4s.	4252 13 4
5s. 4d.		£17010 13 4

Ex. 4*th*, 3664 at 14s. 9d.

10s.	$=\frac{1}{2}$	£1832
5s.	$=\frac{1}{2}$ of 10s.	916
15s.		2748
3d.	$=\frac{1}{20}$ of 5s.	45 16
14s. 9d.		£2702 4

Method 3. If the price contain a composite number of pence, we may multiply the value at a penny by the component parts.

Ex. 5628 at 2s. 11d. or 35d.

```
12)5628
20)469
   £23 9
      5
  £117 5
      7
  £820 15
```

CASE VII. *When the rate consists of pounds and lower denominations.*

Method 1. Multiply by the pounds, and find the value of the other denominations from the proportion which they bear to the pounds.

Ex. 1*st*, 3592 at £3. 12s. 8d.

		3
£3		10776
12s.	$=\frac{1}{5}$ of £3	2155 4
8d.	$=\frac{1}{18}$ of 12s.	119 14 8
£3 12 8		£13050 18 8

Ex. 2*d*, 543 at £2. 5s. $10\frac{1}{2}$d. Practice.

		2
£2		1086
5s.	$=\frac{1}{4}$ of £1	135 15
10d.	$=\frac{1}{6}$ of 5s.	22 12 6
$\frac{1}{2}$d.	$=\frac{1}{20}$ of 10d.	1 2 $7\frac{1}{2}$
£2 5 $10\frac{1}{2}$		£1245 10 $1\frac{1}{5}$

Method 2. Reduce the pounds to shillings, and proceed as in Case VI.

Ex. 1*st*, 3592 at £3. 12s. 8d.

		72 20
		7184 72
		25144
		258624
4d.	$=\frac{1}{3}$s.	1197 4
4d.	$=\frac{1}{3}$s.	1197 4
8d.		261018 8
		£13050 18 8

Ex. 2d, 3683. at £2. 4s. 11d.

		45
		18415
		14732
		165735
At 45s.		
At 1d.	$=\frac{1}{12}$s.	307 11
44s. 11d.		165427 0 1
		£8271 7 1

We have hitherto explained the various methods of computation when the quantity is a whole number and in one denomination. It remains to give the proper directions when the quantity contains a fraction, or is expressed in several denominations.

When the quantity contains a fraction, work for the integers by the preceding rules, and for the fraction take proportional parts.

When the quantity is expressed by several denominations, and the rate given for the higher, calculate the higher, consider the lower one as fractions, and work by the last rule.

When the rate is given for the lower denomination, reduce the higher denomination to the lower, and calculate accordingly.

Note 1. 7 lb. 14 lb. and 21 lb. are aliquot parts of 1 qr.; and 16 lb. is $\frac{1}{7}$ of 1 cwt.; and are therefore easily calculated.

2. If the price of a dozen be so many shillings, that of an article is as many pence; and if the price of a gross be so many shillings, that of a dozen is as many pence.

3. If the price of a ton or score be so many pounds, that of 1 cwt., or a single article, is as many shillings.

4. Though a fraction less than a farthing is of no consequence, and may be rejected, the learner must be careful lest he lose more than a farthing, by rejecting several remainders in the same calculation.

SECT. II.—DEDUCTIONS ON WEIGHTS, &c.

The full weight of any merchandise, together with that of the cask, box, or other package, in which it is contained, is called the *gross weight.* From this we must make proper deductions in order to discover the quantity for which price or duty should be charged, which is called the *nett weight.*

Tare is the allowance for the weight of the package; and this should be ascertained by weighing it before the goods are packed. Sometimes, however, particularly in payment of duty, it is customary to allow so much per cwt. or so much per 100 lb. in place of tare.

Tret is an allowance of 4 lb. on 104 granted on currants and other goods on which there is waste, in order that the weight may answer when the goods are retailed.

Cloff or Draught is a further allowance granted on some goods in London of 2 lb. on every 3 cwt. to turn the scale in favour of the purchaser. The method of calculating these, and the like, will appear from the following examples.

Commission, &c.

Ex. 1*st*, What is the nett weight of 17 cwt. 2 q. 14 lb., tare 18 lb. per cwt.

	Cwt.	q.	lb.		Cwt.	q.	lb.
	17	2	14	gross, or	17	2	14
							6
16 lb.=$\frac{1}{7}$ cwt.	2	2	2				
2 lb.=$\frac{1}{8}$ of 16 lb.		1	$7\frac{1}{4}$		105	3	–
18 lb.	2	3	$9\frac{1}{4}$	tare			3
					317	1	–
	14	3	$4\frac{3}{4}$	nett.	28) $317\frac{1}{4}$ lb.		
					4) 11	$9\frac{1}{4}$	(2 3 $9\frac{1}{4}$ tare.

In the first method we add the tare at 16 lb., which is $\frac{1}{7}$ of the gross weight, to the tare at 2 lb., which is $\frac{1}{8}$ of the former. In the second we multiply the gross weight by 18; the tare is 1 lb. for each cwt. of the product, and is reduced by division to higher denominations.

Ex. 2*d*, What is the tret of 158 cwt. 3 q. 4 lb.

	Cwt.	q.	lb.		Cwt.	q.	lb.	
26)	158	3	4	(	6	0	12	tret.
	156							
	2							
	4							
	11							
	28							
	312							
	312							

Because tret is always 4 lb. in 104, or 1 lb. in 26, it is obtained by dividing by 26.

3*d*, What is the cloff on 28 cwt. 2 q.?

	Cwt.	q.	
	28	2	
		2	
3)	57		(19 lb.

This allowance being 2 lb. on every 3 cwt., might be found by taking $\frac{1}{3}$ of the number of cwts. and multiplying it by 2. It is better to begin with multiplication, for the reason given, p. 550, col. 2, par. 2.

SECT. III.—COMMISSION, &c.

It is frequently required to calculate allowances on sums of money, at the rate of so many per £100. Of this kind is COMMISSION, or the allowance due to a factor for buying or selling goods, or transacting any other business; PREMIUM OF INSURANCE, or allowance given for engaging to repay one's losses at sea or otherwise; EXCHANGE, or the allowance necessary to be added or subtracted for reducing the money of one place to that of another; PREMIUMS ON STOCK, or the allowance given for any share of a public stock above the original value. All these, and others of a like kind, are calculated by the following

RULE.—*Multiply the sum by the rate, and divide the product by* 100. *If the rate contain a fraction, take proportional parts.*

Ex. What is the commission on £728 at $2\frac{3}{4}$ per cent.?

	728
	2
2 per cent.	1456
$\frac{1}{2}$	364
$\frac{1}{4}$	182
	1|00)20|02
	20
	40
	12
	4|80
	4 Answ. £20 0 $4\frac{3}{4}$
	3|20

When the rate is given in guineas, which is common in cases of insurance, you may add a twentieth part to the sum before you calculate; or you may calculate at an equal number of pounds, and add a twentieth part to the answer.

When the given sum is an exact number of 10 pounds, the calculation may be done without setting down any figures. Every £10 at $\frac{1}{2}$ per cent. is a shilling, and at other rates in proportion. Thus, £170 at $\frac{1}{2}$ per cent. is 17s., and at $\frac{1}{4}$ per cent. 8s. 6d.

SECT. IV.—INTEREST.

Interest is the allowance given for the use of money by the borrower to the lender. This is computed at so many pounds for each hundred lent for a year, and a like proportion for a greater or a less time. The highest rate is limited by our laws to 5 per cent. which is called the *legal interest*, and is due on all debts constituted by bond or bill, which are not paid at the proper term; and it is always understood when no other rate is mentioned.

The interest of any sum for a year, at any rate, is found by the method explained in the last section.

The interest of any number of pounds for a year at 5 per cent. is one twentieth part, or an equal number of shillings. Thus the interest of £34675 for a year is 34675 shillings.

The interest for a day is obtained by dividing the interest for a year by the number of days in a year. Thus the interest of £34675 for a day is found by dividing 34675 shillings by 365, and comes to 95 shillings.

The interest for any number of days is obtained by multiplying the daily interest by the number of days. Thus the interest of £34675 for 17 days is 17 times 95 shillings, or 1615 shillings; and this divided by 20, in order to reduce it, comes to £80. 15s.

It would have served the same purpose, and been easier, to multiply at first by 17, the number of days; and instead of dividing separately by 365, and by 20, to divide at once by 7300, the product of 365 multiplied by 20; and this division may be facilitated by the table inserted p. 549, col. 1.

The following practical rules may be inferred from the foregoing observations.

I. To calculate interest at 5 per cent.

Multiply the principal by the number of days, and divide the product by 7300.

II. To calculate interest at any other rate.

Find what it comes to at 5 *per cent. and take a proper proportion of the same for the rate required.*

Ex. 1*st*, Interest on £34675 for 17 days, at 5 per cent.

		£	s.
	34675		
	17		
	242725		
	34675		
73|00)	5894|75	(80	15
	584		
	5475		
	20		
	1095|00		
	73		
	365		
	365		
	0		

Ex. 2*d*, Interest on £304. 3s. 4d. for 8 days, at 4 per cent.

```
        £304  3  4
                 8
                          s.  d.
73|00)2433  6  8(6  8
        20
      486|66
      438
       4866
         12
      584|00
      584
        0
```

Interest at 5 per cent.	£0	6	8
Deduct $\frac{1}{3}$	0	1	4
Interest at 4 per cent.	£0	5	4

Chap. VIII.—Vulgar Fractions.

In order to understand the nature of vulgar fractions, we must suppose unity (or the number 1) divided into several equal parts. One or more of these parts is called a *fraction*, and is represented by placing one number in a small character above a line, and another under it: For example, two fifth parts is written thus, $\frac{2}{5}$. The number under the line (5) shows how many parts unity is divided into, and is called the *denominator*. The number above the line (2) shows how many of these parts are represented, and is called the *numerator*.

It follows, from the manner of representing fractions, that when the numerator is increased, the value of the fraction becomes greater; but when the denominator is increased, the value becomes less. Hence we may infer, that if the numerator and denominator be both increased, or both diminished, in the same proportion, the value is not altered; and therefore, if we multiply both by any number whatever, or divide them by any number which measures both, we shall obtain other fractions of equal value. Thus, every fraction may be expressed in a variety of forms, which have all the same signification.

A fraction annexed to an integer or whole number makes a mixed number; for example, five and two third parts, or $5\frac{2}{3}$. A fraction whose numerator is greater than its denominator is called an *improper fraction;* for example, seventeen third parts, or $\frac{17}{3}$. Fractions of this kind are greater than unity. Mixed numbers may be represented in the form of improper fractions, and improper fractions may be reduced to mixed numbers, and sometimes to integers. As fractions, whether proper or improper, may be represented in different forms, we must explain the method of reducing them from one form to another before we consider the other operations.

Problem I.—To reduce mixed numbers to improper fractions.

Multiply the integer by the denominator of the fraction, and to the product add the numerator. The sum is the numerator of the improper fraction sought, and is placed above the given denominator.

Ex. $5\frac{2}{3} = \frac{17}{3}$.

5 integer.
3 denominator.
15 product.
2 numerator given.
17 numerator sought.

Because one is equal to two halves, or 3 third parts, or 4 quarters, and every integer is equal to twice as many halves, or four times as many quarters, and so on, therefore, every integer may be expressed in the form of an improper fraction, having an assigned denominator. The numerator is obtained by multiplying the integer into the denominator. Hence the reason of the foregoing rule is evident: 5 reduced to an improper fraction whose denominator is 3, makes $\frac{15}{3}$, and this added to $\frac{2}{3}$ amounts to $\frac{17}{3}$.

Problem II.—To reduce improper fractions to whole or mixed numbers,

Divide the numerator by the denominator.

Ex. $\frac{112}{17} = 6\frac{10}{17}$.

```
17)112(6 10/17
   102
    10
```

This problem is the converse of the former, and the reason may be illustrated in the same manner.

Problem III.—To reduce fractions to lower terms.

Divide both numerator and denominator by any number which measures both, and place the quotients in the form of a fraction.

Example. $\frac{135}{360} = \frac{27}{72} = \frac{3}{8}$.

Here we observe that 135 and 360 are both measured by 5, and the quotients form $\frac{27}{72}$, which is a fraction of the same value as $\frac{135}{360}$ in lower terms. Again, 27 and 72 are both measured by 9, and the quotients form $\frac{3}{8}$, which is still of equal value, and in lower terms.

It is generally sufficient, in practice, to divide by such measures as are found to answer on inspection, or by the rules given p. 547, col. 2. But if it be required to reduce a fraction to the lowest possible terms, we must divide the numerator and denominator by the greatest number which measures both. What number this is may not be obvious, but will always be found by the following rule.

To find the greatest common measure of two numbers, divide the greater by the lesser and the divisor by the remainder continually till nothing remains; the last divisor is the greatest common measure.

Ex. Required the greatest number which measures 475 and 589?

```
475)589(1
    475
    114)475(4
        456
         19)114(6
            114
              0
```

Here we divide 589 by 475, and the remainder is 114; then we divide 475 by 114, and the remainder is 19; then we divide 114 by 19, and there is no remainder; from which we infer that 19, the last divisor, is the greatest common measure.

To explain the reason of this, we must observe, that any number which measures two others will also measure their sum and their difference, and will measure any multiple of either. In the foregoing example, any number which measures 589 and 475 will measure their difference, 114, and will measure 456, which is a multiple of 114; and any number which measures 475 and 456 will also measure their difference, 19. Consequently, no number greater than 19 can measure 589 and 475. Again, 19 will measure them both, for it measures 114, and therefore measures 456, which is a multiple of 114 and 475, which is just 19 more than 456; and because it measures 475 and 114, it will measure their sum, 589. To reduce $\frac{475}{589}$ to the lowest possible terms, we divide both numbers by 19, and it comes to $\frac{25}{31}$.

If there be no common measure greater than 1, the fraction is already in the lowest terms.

If the greatest common measure of 3 numbers be required, we find the greatest measure of the two first, and then the greatest measure of that number and the third. If there be more numbers, we proceed in the same manner.

Problem IV.—To reduce fractions to others of equal value that have the same denominator.

1st, *Multiply the numerator of each fraction by all the deno-*

Vulgar Fractions.

minators except its own; the products are numerators to the respective fractions sought. 2d, *Multiply all the denominators into each other; the product is the common denominator.*

Ex. $\frac{4}{5}$ and $\frac{7}{9}$ and $\frac{3}{8} = \frac{288}{360}$ and $\frac{280}{360}$ and $\frac{135}{360}$.

$4 \times 9 \times 8 = 288$ first numerator.
$7 \times 5 \times 8 = 280$ second numerator.
$3 \times 5 \times 9 = 135$ third numerator.
$5 \times 9 \times 8 = 360$ common denominator.

Here we multiply 4, the numerator of the first fraction, by 9 and 8, the denominators of the two others; and the product, 288, is the numerator of the fraction sought, equivalent to the first. The other numerators are found in like manner, and the common denominator, 360, is obtained by multiplying the given denominators 5, 9, 8, into each other. In the course of the whole operation, the numerators and denominators of each fraction are multiplied by the same number, and therefore their value is not altered.

The fractions thus obtained may be reduced to lower terms, if the several numerators and denominators have a common measure greater than unity. Or, after arranging the number for multiplication, as is done above, if the same number occur in each rank, we may dash them out and neglect them; and if numbers which have a common measure occur in each, we may dash them out and use the quotients in their stead; or any number which is a multiple of all the given denominators may be used as a common denominator. Sometimes a number of this kind will occur on inspection, and the new numerators are found by multiplying the given ones by the common denominator, and dividing the products by the respective given denominators.

If the articles given for any operation be mixed numbers, they are reduced to improper fractions by Problem I. If the answer obtained be an improper fraction, it is reduced to a mixed number by Problem II. And it is convenient to reduce fractions to lower terms, when it can be done, by Problem III. which makes their value better apprehended, and facilitates any following operation. The reduction of fractions to the same denominator by Problem IV. is necessary to prepare them for addition or subtraction, but not for multiplication or division.

SECT. I.—ADDITION OF VULGAR FRACTIONS.

RULE.—*Reduce them, if necessary, to a common denominator; add the numerators, and place the sum above the denominator.*

Ex. 1*st*, $\frac{3}{5} + \frac{2}{9} = \frac{27}{45} + \frac{10}{45}$ by Problem IV. $= \frac{37}{45}$

2*d*, $\frac{5}{7} + \frac{8}{9} + \frac{9}{10} = \frac{450}{630} + \frac{560}{630} + \frac{567}{630} = \frac{1377}{630}$ by Problem II. $= 2\frac{317}{630}$.

The numerators of fractions that have the same denominator signify like parts; and the reason for adding them is equally obvious as that for adding shillings or any other inferior denomination.

Mixed numbers may be added by annexing the sum of the fractions to the sum of the integers. If the former be a mixed number, its integer is added to the other integers.

SECT. II.—SUBTRACTION OF VULGAR FRACTIONS.

RULE.—*Reduce the fractions to a common denominator; subtract the numerator of the subtrahend from the numerator of the minuend, and place the remainder above the denominator.*

Ex. Subtract $\frac{2}{7}$ from $\frac{5}{12}$ remainder $\frac{11}{84}$

$\left.\begin{array}{l}\frac{5}{12} = \frac{35}{84}\\ \frac{2}{7} = \frac{24}{84}\end{array}\right\}$ by Prob. IV. from 35, take 24, remainder 11.

To subtract a fraction from an integer, subtract the numerator from the denominator, and place the remainder above the denominator; prefix to this the integer diminished by unity.

Ex. Subtract $\frac{3}{5}$ from 12. remainder $11\frac{2}{5}$.

To subtract mixed numbers, proceed with the fractions by the foregoing rule, and with the integers in the common method. If the numerator of the fraction in the subtrahend exceed that in the minuend, borrow the value of the denominator, and repay it by adding 1 to the unit place of the subtrahend.

Ex. Subtract $145\frac{7}{9}$ from $248\frac{3}{5}$

$\left.\begin{array}{l}\frac{3}{5} = \frac{27}{45}\\ \frac{7}{9} = \frac{35}{45}\end{array}\right\}$ by Prob. IV.

$$\begin{array}{r} 248\frac{27}{45} \\ 145\frac{35}{45} \\ \hline 102\frac{37}{45} \end{array}$$

Here, because 27, the numerator of the fraction in the minuend, is less than 35, the numerator of the subtrahend, we borrow 45, the denominator; 27 and 45 make 72, from which we subtract 35, and obtain 37 for the numerator of the fraction in the remainder; and we repay what was borrowed, by adding 1 to 5 in the unit place of the subtrahend.

The reason of the operations in adding or subtracting fractions will be fully understood if we place the numerators of the fractions in a column like a lower denomination, and add or subtract them as integers, carrying or borrowing according to the value of the high denomination.

SECT. III.—MULTIPLICATION OF VULGAR FRACTIONS.

RULE.—*Multiply the numerators of the factors together for the numerator of the product, and the denominators together for the denominator of the product.*

Ex. 1*st*, $\frac{2}{3} \times \frac{5}{7} = \frac{10}{21}$
$2 \times 5 = 10$ num.
$3 \times 7 = 21$ den.

2*d*, $8\frac{2}{5} \times 7\frac{3}{4} = \frac{1302}{20} = 65\frac{2}{20}$
$8\frac{2}{5} = \frac{42}{5}$ by Prob. I.
$7\frac{3}{4} = \frac{31}{4}$ by ditto
$42 \times 31 = 1302$
$5 \times 4 = 20$

To multiply $\frac{5}{7}$ by $\frac{2}{3}$ is the same as to find what two third parts of $\frac{5}{7}$ comes to. If one third part only had been required, it would have been obtained by multiplying the denominator 7 by 3, because the value of fractions is lessened when their denominators are increased: and this comes to $\frac{5}{21}$; and, because two thirds were required, we must double that fraction, which is done by multiplying the numerator by 2, and comes to $\frac{10}{21}$. Hence we infer that fractions of fractions, or compound fractions, such as $\frac{2}{7}$ of $\frac{3}{5}$, are reduced to simple ones by multiplication. The same method is followed when the compound fraction is expressed in three parts or more.

The foregoing rule extends to every case when there are fractions in either factor. For mixed numbers may be reduced to improper fractions, as is done in *Ex.* 2; and integers may be written, or understood to be written, in the form of fractions whose numerator is 1. It will be convenient, however, to give some further directions for proceeding when one of the factors is an integer, or when one or both are mixed numbers.

1*st*, To multiply an integer by a fraction, multiply it by the numerator, and divide the product by the denominator.

Ex. $3756 \times \frac{3}{5} = 2253\frac{3}{5}$

$$\begin{array}{r} 3 \\ \hline 5)11268(2253\frac{3}{5} \end{array}$$

2*d*, To multiply an integer by a mixed number, we multiply it first by the integer and then by the fraction, and add the products.

Ex. $138 \times 5\frac{3}{4} = 793\frac{1}{2}$

$$\begin{array}{r} 138 \times 5 = 690 \\ 138 \times \frac{3}{4} \\ 3 \\ \hline 4)414(\quad 103\frac{1}{2} \\ \hline 793\frac{1}{2} \end{array}$$

3d, To multiply a mixed number by a fraction, we may multiply the integer by the fraction, and the two fractions together, and add the products.

Ex. $15\frac{3}{8} \times \frac{2}{9} = 3\frac{5}{12}$

$15 \times \frac{2}{9} = 3\frac{3}{9} = 3\frac{4}{12}$

$\frac{3}{8} \times \frac{2}{9} = \frac{6}{72} = \frac{1}{12}$

$3\frac{5}{12}$

4th, When both factors are mixed numbers, we may multiply each part of the multiplicand, first by the integer of the multiplier, and then by the fraction, and add the four products.

Ex. $8\frac{2}{3}$ by $7\frac{3}{4}$

$8 \times 7 =$ 56

$8 \times \frac{3}{4} = \frac{24}{4} =$ 6 by Prob. II.

$\frac{2}{3} \times 7 = \frac{14}{3} = 2\frac{4}{3}$ $2\frac{16}{20}$

$\frac{2}{3} \times \frac{3}{4} =$ $\frac{6}{20}$

product $65\frac{2}{20}$ as before.

SECT. IV.—DIVISION OF VULGAR FRACTIONS.

RULE I.—*Multiply the numerator of the dividend by the denominator of the divisor. The product is the numerator of the quotient.*

II.—*Multiply the denominator of the dividend by the numerator of the divisor. The product is the denominator of the quotient.*

Ex. Divide $\frac{2}{3}$ by $\frac{7}{9}$. quotient $\frac{18}{35}$.

$2 \times 9 = 18$

$5 \times 7 = 35.$

To explain the reason of this operation, let us suppose it required to divide $\frac{2}{3}$ by 7, or to take one seventh part of that fraction. This is obtained by multiplying the denominator by 7; for the value of fractions is diminished by increasing their denominators, and comes to $\frac{2}{35}$. Again, because $\frac{7}{9}$ is nine times less than seven, the quotient of any number divided by $\frac{7}{9}$ will be nine times greater than the quotient of the same number divided by 7. Therefore we multiply $\frac{2}{35}$ by 9, and obtain $\frac{18}{35}$.

If the divisor and dividend have the same denominator, it is sufficient to divide the numerators.

Ex. $\frac{12}{17}$ divided by $\frac{3}{17}$ quotes 4.

The foregoing rule may be extended to every case by reducing integers and mixed numbers to the form of improper fractions. We shall add some directions for shortening the operation when integers and mixed numbers are concerned.

1st, When the dividend is an integer, multiply it by the denominator of the divisor, and divide the product by the numerator.

Ex. Divide 368 by $\frac{5}{7}$

7

5)2576($515\frac{1}{5}$ quotient.

2d, When the divisor is an integer, and the dividend a fraction, multiply the denominator by the divisor, and place the product under the numerator.

Ex. Divide $\frac{3}{8}$ by 5 quotient $\frac{3}{40}$

$8 \times 5 = 40$

3d, When the divisor is an integer, and the dividend a mixed number, divide the integer, and annex the fraction to the remainder; then reduce the mixed number thus formed to an improper fraction, and multiply its denominator by the divisor.

Ex. To divide $576\frac{4}{11}$ by 7 quotient $82\frac{26}{77}$

7) 576 (82
56
16
14

$2\frac{4}{11} = \frac{26}{11}$

$11 \times 7 = 77$

Here we divide 576 by 7, the quotient is 82, and the remainder 2, to which we annex the fraction $\frac{4}{11}$, and reduce $2\frac{4}{11}$ to an improper fraction $\frac{26}{11}$, and multiply its denominator by 7, which gives $\frac{26}{77}$.

Hitherto we have considered the fractions as abstract numbers, and laid down the necessary rules accordingly. We now proceed to apply these to practice. Shillings and pence may be considered as fractions of pounds, and lower denominations of any kind as fractions of higher; and any operation, where different denominations occur, may be wrought by expressing the lower ones in one form of vulgar fractions, and proceeding by the following rules. For this purpose the two following problems are necessary.

PROBLEM V.—To reduce lower denominations to fractions of higher.

Place the given number for the numerator, and the value of the higher for the denominator.

Examples.

1. Reduce 7d. to the fraction of a shilling. Ans. $\frac{7}{12}$.
2. Reduce 7d. to a fraction of a pound. Ans. $\frac{7}{240}$.
3. Reduce 15s. 7d. to a fraction of a pound. Ans. $\frac{187}{240}$.

PROBLEM VI.—To value fractions of higher denominations.

Multiply the numerator by the value of the given denomination, and divide the product by the denominator; if there be a remainder, multiply it by the value of the next denomination, and continue the division.

Ex. 1*st*, Required the value of $\frac{17}{60}$ of £1.

17
20
— *s.* *d.*
60)340(5 8
300
—
40
12
—
60)480
480
—

2*d*, Required the value of $\frac{8}{9}$ of 1 cwt.

8
4
— *qrs.* *lb.*
9)32(3 $15\frac{5}{9}$
27
—
5
28
—
9)140
9
—
50
45
—
5

In the first example we multiply the numerator 17 by 20, the number of shillings in a pound, and divide the product, 340, by 60, the denominator of the fraction, and obtain a quotient of 5 shillings; then we multiply the remainder, 40, by 12, the number of pence in a shilling, which produces 480, which, divided by 60, quotes 8d. without a remainder. In the second example we proceed in the same manner; but as there is a remainder, the quotient is completed by a fraction.

Sometimes the value of the fraction does not amount to an unit of the lowest denomination; but it may be reduced to a fraction of that or any other denomination by multiplying the numerator according to the value of the places. Thus $\frac{1}{1289}$ of a pound is equal to $\frac{12}{1289}$ of a shilling, or $\frac{240}{1289}$ of a penny, $\frac{960}{1289}$ of a farthing.

CHAP. IX.—DECIMAL FRACTIONS.

SECT. I.—NOTATION AND REDUCTION.

Decimal fractions are such as have 10, or some power of 10 (that is 100, 1000, &c.), for a denominator: such are these,—

$\frac{3}{10}$, $\frac{24}{100}$, $\frac{75}{1000}$, $\frac{462}{100000}$;

They are more simply written thus:

·3, ·24, ·075, ·00462;

the number of figures after the point being always the same as the number of ciphers in the denominators.

In decimal fractions, as thus written, the figure next

the point, to the right, indicates so many tenths; the next so many hundredths, and so on. Thus, in the fraction ·346, the figure 3 expresses 3 tenths, 4 denotes 4 hundredths, and 6, 6 thousandths.

The use of ciphers in decimals, as well as in integers, is to bring the significant figures to their proper places, on which their value depends. As ciphers, when placed on the left hand of an integer, have no signification, but, when placed on the right hand, increase the value ten times each; so ciphers, when placed on the right hand of a decimal, have no signification, but when placed on the left hand, diminish the value ten times each.

The notation and numeration of decimals will be obvious from the following examples:

4·7 signifies four, and seven tenth parts.
·47 four tenth parts, and seven hundredth parts, or 47 hundredth parts.
·047 four hundredth parts, and seven thousandth parts, or 47 thousandth parts.
·407 four tenth parts, and seven thousandth parts, or 407 thousandth parts.
4·07 four, and seven hundredth parts.
4·007 four, and seven thousandth parts.

To reduce vulgar fractions to decimal ones. *Annex a cipher to the numerator, and divide it by the denominator, annexing a cipher continually to the remainder.*

Ex. 1*st*, $\frac{12}{75}$=·16
75)120(16
75
450
450

2*d*, $\frac{5}{64}$=·078125
64)500(078125
448
520
512
80
64
160
128
320
320

3*d*, $\frac{2}{3}$=·666
3)20(666
18
20
18
20
18
20

4*th*, $\frac{5}{6}$=·833
6)50(833
48
20
18
20
18
20

5*th*, $\frac{7}{27}$=·259
27)70(259
54
160
135
250
243
7

6*th*, $\frac{7}{22}$=·3,18,18.
22)70(31818
66
40
22
180
176
40
22
18

The reason of this operation will be evident, if we consider that the numerator of a vulgar fraction is understood to be divided by the denominator; and this division is actually performed when it is reduced to a decimal.

In like manner, when there is a remainder left in division, we may extend the quotient to a decimal, instead of completing it by a vulgar fraction, as in the following example:

25)646(25$\frac{21}{25}$ or 25·84.
50
146
125
Rem. 21·0
200
100
100

From the foregoing examples we may distinguish the several kinds of decimals. Some vulgar fractions may be reduced exactly to decimals, as Ex. 1*st* and 2*d*, and are called *terminate* or *finite decimals.* Others cannot be exactly reduced, because the division always leaves a remainder; but, by continuing the division, we will perceive how the decimal may be extended to any length whatever. These are called *infinite decimals.* If the same figure continually returns, as in Ex. 3*d* and 4*th*, they are called *repeaters.* If two or more figures return in their order, they are called *circulates.* If this regular succession go on from the beginning, they are called *pure repeaters*, or *circulates*, as Ex. 3*d* and 5*th*. If otherwise, as Ex. 4*th* and 6*th*, they are mixed *repeaters* or *circulates*, and the figures prefixed to those in regular succession are called the *finite part.* Repeating figures are generally distinguished by a dash, and circulates by a comma or other mark, at the beginning and end of the circle; and the beginning of a repeater or circulate is pointed out in the division by an asterisk.

Lower denominations may be considered as fractions of higher ones, and reduced to decimals accordingly. We may proceed by the following rule, which is the same in effect as the former.

To reduce lower denominations to decimals of higher. *Annex a cipher to the lower denomination, and divide it by the value of the higher. When there are several denominations, begin at the lowest, and reduce them in their order.*

Ex. To reduce 5 cwt. 2 qr. 21 lb. to a decimal of a ton.

28)210(·75
196
140
140

4)2·75(·6875
24
35
32
30
28
20
20

20)5·6875(·284375
40
168
160
87
80
75
60
150
140
100
100

Here, in order to reduce 21 lb. to a decimal of 1 qr. we annex a cipher, and divide by 28, the value of 1 qr. This gives ·75. Then we reduce 2·75 qrs. to a decimal of 1 cwt. by dividing by 4, the value of 1 cwt., and it comes to ·6875. Lastly, 5·6875 cwt. is reduced to a decimal of a ton by dividing by 20, and comes to ·284375.

To value a decimal fraction. *Multiply it by the value of the denomination, and cut off as many decimal places from the product as there are in the multiplicand. The rest are integers of the lower denomination.*

Example. What is the value of ·425 of £1?

·425
20
sh. 8·500
6
d. 3·000

SECT. II.—ARITHMETIC OF TERMINATE DECIMALS.

The value of decimal places decreases like that of integers, ten of the lower place in either being equal to one of the next higher; and the same holds in passing from decimals to integers. Therefore, all the operations are performed in the same way with decimals, whether placed by themselves or annexed to integers, as with pure integers. The only peculiarity lies in the arrangement and pointing of the decimals.

In addition and subtraction, *Arrange units under units, tenth parts under tenth parts, and proceed as in integers.*

32·035	from 13·348	and 12·248
116·374	take 9·2993	10·6752
160·63		
12·3645	4·0487	1·5728
321·4035		

In multiplication, *Allow as many decimal places in the product as there are in both factors. If the product has not so many places, supply them by prefixing ciphers on the left hand.*

Ex. 1*st*,	1·37	2*d*, 43·75	3*d*, ·1572
	1·8	·48	·12
	1096	35000	·018864
	137	17500	
	2·466	21·0000	

The reason of this rule may be explained, by observing, that the value of the product depends on the value of the factors; and since each decimal place in either factor diminishes its value ten times, it must equally diminish the value of the product.

To multiply decimals by 10, move the decimal point one place to the right; to multiply by 100, 1000, or the like, move it as many places to the right as there are ciphers in the multiplier.

In division, *Point the quotient so that there may be an equal number of decimal places in the dividend as in the divisor and quotient together.*

Therefore, if there be the same number of decimal places in the divisor and dividend, there will be none in the quotient.

If there be more in the dividend, the quotient will have as many as the dividend has more than the divisor.

If there be more in the divisor, we must annex (or suppose annexed) as many ciphers to the dividend as may complete the number in the divisor, and all the figures of the quotient are integers.

If the division leave a remainder, the quotient may be extended to more decimal places; but these are not regarded in fixing the decimal point.

The reason for fixing the decimal point as directed may be inferred from the rule followed in multiplication. The quotient multiplied by the divisor produces the dividend; and therefore the number of decimal places in the dividend is equal to those in the divisor and quotient together.

The first figure of the quotient is always at the same distance from the decimal point, and on the same side, as the figure of the dividend which stands above the unit place of the first product. This also takes place in integers; and the reason is the same in both.

Multiplication by fractions corresponds with division by integers, and division by fractions with multiplication by integers; when we multiply by $\frac{1}{2}$ or ·5, we obtain the same answer as when we divide by 2, and every integer has a correspondent decimal, which may be called its *reciprocal.* Multiplication by that decimal supplies the place of division by the integer, and division supplies the place of multiplication.

To find the reciprocal of any number, divide 1 with ciphers annexed by that number.

Ex. Required the reciprocal of 625.

```
625)1·000(·0016
    625
    ----
    3750
    3750
    ----
       0
```

The product of any number multiplied by ·0016 is the same as the quotient divided by 625.

```
Ex. 625)9375(15
        625
        ----
        3125
        3125
        ----
           0
```

9375	
·0016	
56250	
9375	
15·0000	

Because ·0016 is $\frac{1}{625}$ of unity, any number multiplied by that fraction will be diminished 625 times. For a like reason, the quotient of any number divided by ·0016 will be equal to the product of the same multiplied by 625.

```
Ex. ·0016)516·0000(322500
          48· · · ·
          ---
           36
           32
           --
            40
            32
            --
             80
             80
             --
              0
```

516
625
2580
1032
3096
322500

SECT. III.—APPROXIMATE DECIMALS.

It has been shown that some decimals, though extended to any length, are never complete; and others, which terminate at last, sometimes consist of so many places that it would be difficult in practice to extend them fully. In these cases, we may extend the decimal to three, four, or more places, according to the nature of the articles and the degree of accuracy required, and reject the rest of it as inconsiderable. In this manner we may perform any operation with ease by the common rules, and the answers we obtain are sufficiently exact for any purpose in business. Decimals thus restricted are called *approximates.*

Shillings, pence, and farthings, may be easily reduced to decimals of three places by the following rule: Take half the shillings for the first decimal place, and the number of farthings increased by one, if it amount to 24 or upwards; by two, if it amount to 48 or upwards; and by three, if it amount to 72 or upwards, for the two next places.

The reason of this is, that 20 shillings make a pound, two shillings is the tenth part of a pound, and therefore half the number of shillings makes the first decimal place. If there were 50 farthings in a shilling, or 1000 in a pound, the units of the farthings in the remainder would be thousandth parts, and the tens would be hundredth parts, and so would give the two next decimal places; but because there are only 48 farthings in a shilling, or 960 in a pound, every farthing is a little more than the thousandth part of a pound; and since 24 farthings make 25 thousandth parts, allowance is made for that excess by adding 1 for every 24 farthings, as directed.

If the number of farthings be 24, 48, or 72, and consequently the second and third decimal places 25, 50, and 75, they are exactly right; otherwise they are not quite complete, since there should be an allowance of $\frac{1}{24}$, not only for 24, 48, and 72 farthings, but for every other single farthing. They may be completed by the following rule: multiply the second and third decimal places, or their excess above 25, 50, 75, by 4. If the product amount to 24 or upwards, add 1; if 48, add 2; if 72, add 3. By this operation we obtain two decimal places more; and by continuing the same operation, we may extend the decimal till it terminate in 25, 50, 75, or in a repeater.

Decimals of sterling money of three places may easily be reduced to shillings, pence, and farthings, by the following rule: Double the first decimal place, and if the second be 5 or upwards, add 1 thereto for shillings. Then divide the second and third decimal places, or their excess above 50, by 4, first deducting 1, if it amount to 25

or upwards; the quotient is pence, and the remainder farthings.

As this rule is the converse of the former one, the reason of the one may be inferred from that of the other. The value obtained by it, unless the decimal terminate in 25, 50, or 75, is a little more than the true value; for there should be a deduction, not only of 1 for 25, but a little deduction of $\frac{1}{25}$ on the remaining figures of these places.

We proceed to give some examples of the arithmetic of approximates, and subjoin any necessary observations.

ADDITION.

Cwt.	qrs.	lb.	
3	2	14	= 3·625
2	3	22	= 2·94642
3	3	19	= 3·91964
4	1	25	= 4·47321
14	3	24	14·96427

SUBTRACTION.

Cwt.	qrs.	lb.	
3	2	2	= 3·51785
1	1	19	= 1·41964
2	–	11	2·09821

If we value the sum of the approximates, it will fall a little short of the sum of the articles, because the decimals are not complete.

It is proper to add 1 to the last decimal place of the approximate, when the following figure would have been 5 or upwards. Thus the full decimal of 3 qrs. 22 lb. is ·946,428571, and therefore ·94643 is nearer to it than ·946,42. Approximates thus regulated will give exacter answers, sometimes above the true one and sometimes below it.

The mark + signifies that the approximate is less than the exact decimal, or requires something to be added. The mark — signifies that it is greater, or requires something to be subtracted.

MULTIPLICATION.

Meth. 1st,	Meth. 2d,	Meth. 3d,
8278+	8278	8278
2153+	2153	3512
24834	16556 |	16556
41390	827 | 8	827
8278	413 | 90	413
16556	24 | 834	24
1782|2534	1782|2534	1782

Here the last four places are quite uncertain. The right-hand figure of each particular product is obtained by multiplying 8 into the figures of the multiplier; but if the multiplicand had been extended, the carriage from the right-hand place would have been taken in; consequently the right-hand place of each particular product, and the four places of the total product, which depend on these, are quite uncertain. Since part of the operation therefore is useless, we may omit it; and for this purpose it will be convenient to begin (as in p. 547, col. 1, *fifth* variety) at the highest place of the multiplier. We may perceive that all the figures on the right hand of the line in Meth. 2 serve no purpose, and may be left out if we only multiply the figures on the multiplicand, whose products are placed on the left hand of the line. This is readily done by inverting the multiplier in Meth. 3, and beginning each product with the multiplication of that figure which stands above the figure of the multiplier that produces it, and including the carriage from the right-hand place.

If both factors be approximates, there are at least as many uncertain places in the product as in the longest factor. If only one be an approximate, there are as many uncertain places as there are figures in that factor, and sometimes a place or two more, which might be affected by the carriage. Hence we may infer how far it is necessary to extend the approximates in order to obtain the requisite number of certain places in the product.

DIVISION.

·3724 —)798|64237 + (2144 or 3724)79864237(2144

744	8	7448
53	84	538
37	24	372
16	602	166
14	896	148
1	7063	18
1	4896	14
2167		4

Here all the figures on the right hand of the line are uncertain, for the right-hand figure of the first product 7448 might be altered by the carriage if the divisor were extended; and all the remainders and dividuals that follow are thereby rendered uncertain. We may omit these useless figures, for which purpose we dash a figure on the right hand of the divisor at each step, and neglect it when we multiply by the figure of the quotient next obtained; but we include the carriage. The operation, and the reason of it, will appear clear, by comparing the operation at large, and contracted, in the above example.

CHAP. X.—INTERMINATE DECIMALS.

SECT. I.—REDUCTION OF INTERMINATE DECIMALS.

We have seen that some vulgar fractions admit of being converted into exact decimal fractions, while others have not that property, but proceed interminably, the numerator being either the same figure, or else a combination of figures always repeated. The fraction $\frac{3}{8}$ is of the first mentioned kind, its decimal value being $\frac{375}{1000}$, that is ·375; again, $\frac{1}{3}$=·333, &c. and $\frac{5}{7}$=·714285,714285, &c. are examples of the second kind. Let us suppose a fraction reduced to its lowest terms, $\frac{3}{8}$, for example. Now, to convert this into a decimal, we annex ciphers to the numerator (that is, we multiply it by some power of 10), and divide by the denominator, the decimal denominator being always that power of ten by which the numerator was multiplied. In the case of $\frac{3}{8}$, the numerator is multiplied by 1000, which is exactly divisible by 8; for when the numbers are expressed by the product of their simple factors, we have $1000=2\times2\times2\times5\times5\times5$ and $8=2\times2\times2$, and $\frac{1000}{8}=5\times5\times5=125$, therefore the decimal value of $\frac{3}{8}$ is $\frac{375}{1000}$, that is, ·375. Here it appears that the decimal fraction has a finite form, because the divisors of the denominator of the vulgar fraction are also divisors of a power of 10.

A like remark may be made concerning the fraction $\frac{7}{25}=\frac{7}{5\times5}$, the two equal divisors 5 being divisors of 10, and therefore their product a divisor of 100, and the fraction =·28.

In general, it appears that if the simple factors of the denominators of a vulgar fraction be all either 2 or 5, its decimal value will be finite, otherwise not.

The fraction $\frac{1}{9}$ is therefore, from its nature, incapable of being converted into a finite decimal; but this fraction, when converted into a decimal, being ·1111, &c. *ad infinitum*, therefore $\frac{2}{9}$ will be ·222, &c. and $\frac{3}{9}=\frac{1}{3}$ = ·333, &c. and so on to $\frac{8}{9}$, which will be ·888, &c. Hence it is manifest that every repeating decimal is equivalent to a vulgar fraction whose denominator is 9.

Again, since $\frac{1}{99}$ = ·010101, &c. *ad infinitum*, therefore $\frac{2}{99}$ = ·0202, &c.; and in like manner $\frac{17}{99}$ = ·1717, &c. and so on, from $\frac{1}{99}$ to $\frac{89}{99}$, which is equal to ·89,89,89, &c. Therefore every circulating decimal of two figures is convertible into a vulgar fraction whose denominator is 99.

And since $\frac{1}{999}$ = ·001001001, &c., therefore any fraction whose numerator consists of three figures, and deno-

minator 999, must produce a circulate of three figures; for example, $\frac{365}{999} = \cdot 365365365$, &c.; and in like manner, since $\frac{1}{9999} = \cdot 00010001$, &c., therefore every fraction whose numerator consists of not more than four figures, and which has 9999 for a denominator, must produce a circulate of four figures, and so on.

It is now sufficiently manifest that all circulating decimals may be generated from vulgar fractions whose denominators are formed by a repetition of the figure 9; and hence it follows that every circulate may be converted into a vulgar fraction of that form.

RULES for reducing interminate decimals to vulgar fractions.

I. *If the decimal be a pure repeater, place the repeating figure for the numerator, and* 9 *for the denominator.*

II. *If the decimal be a pure circulate, place the circulating figures for the numerator, and as many* 9*'s as there are places in the circle for the denominator.*

III. *If there be ciphers prefixed to the repeating or circulating figures, annex a like number to the* 9*'s in the denominator.*

IV. *If the decimal be mixed, subtract the finite part from the whole decimal. The remainder is the numerator, and the denominator consists of as many* 9*'s as there are places in the circle, together with as many ciphers as there are finite places before the circle.*

Thus, $\cdot 235{,}62, = \frac{23327}{99000}$

From the whole decimal 23562

We subtract the finite part 235

and the remainder 23327 is the numerator.

The reason may be illustrated by dividing the decimal into two parts, whereof one is finite, and the other a pure repeater or circulate, with ciphers prefixed. The sum of the vulgar fractions corresponding to these will be the value of the decimal sought.

$\cdot 235{,}62$ may be divided into $\cdot 235 = \frac{235}{1000}$ by Rule I.
and $\cdot 000{,}62 = \frac{62}{99000}$ by Rules II. III.

In order to add these vulgar fractions, we reduce them to a common denominator; and for that purpose we multiply both terms of the former by 99, which gives $\frac{23265}{99000}$; then we add the numerators.

235, or, by method explained p. 546, col. 1, par. 3,

		Sum of numerators.	
99			
2115	23500	23265 or	23562
2115	235	62	235
23265	23265	23327	23327

The value of circulating decimals is not altered though one or more places be separated from the circle and considered as a finite part, providing the circle be completed. For example, $\cdot 27$ may be written $\cdot 2{,}72$, $\frac{270}{990}$, or $\frac{27}{99}$, which is also the value of $\cdot 27$; and if two or more circles be joined, the value of the decimal is still the same. Thus, $\cdot 2727 = \frac{2727}{9999}$, which is reduced by dividing the terms by 101 to $\frac{27}{99}$.

All circulating decimals may be reduced to a similar form, having a like number both of finite and circulating places. For this purpose, we extend the finite part of each as far as the longest, and then extend all the circles to so many places as may be a multiple of the number of places in each.

Ex. $\cdot 34{,}725$, extended, $\cdot 34{,}725725725725$
$\cdot 1{,}4562$, $\cdot 14{,}562456245624$

Here the finite part of both is extended to two places, and the circle to 12 places, which is the least multiple for circles of 3 and 4 places.

SECT. II.—ADDITION AND SUBTRACTION OF INTERMINATE DECIMALS.

To add repeating decimals. *Extend the repeating figures one place beyond the longest finite ones, and when you add the right-hand column, carry to the next by* 9.

Ex. $\cdot 3752\dot{4}$ or $\cdot 3752\dot{4}$
$\cdot 8$ $\cdot 8888\dot{8}$
$\cdot 643$ $\cdot 643$
$\cdot 73$ $\cdot 7333\dot{3}$
$2\cdot 64046$

To subtract repeating decimals. *Extend them as directed for addition, and borrow at the right-hand place, if necessary, by* 9.

Ex. 1*st*, $\cdot 9356\dot{6}$ *Ex.* 2*d*, $\cdot 646$
$\cdot 8473\dot{8}$ $\cdot 5342\dot{7}$
$\cdot 0882\dot{7}$ $\cdot 1117\dot{2}$

The reason of these rules will be obvious, if we recollect that repeating figures signify ninth parts. If the right-hand figure of the sum or remainder be 0, the decimal obtained is finite; otherwise it is a repeater.

To add circulating decimals. *Extend them till they become similar* (p. 563, col. 1, par. *ult.* &c.); *and when you add the right-hand column, include the figure which would have been carried if the circle had been extended farther.*

Ex. 1*st*,	*Extended.*	*Ex.* 2*d*,	*Extended.*
$\cdot 574$,	$\cdot 574{,}574$,	$\cdot 874$,	$\cdot 874{,}874874$,
$\cdot 2{,}698$,	$\cdot 269{,}869$,	$\cdot 146\dot{3}$	$\cdot 146{,}333333$,
$\cdot 428$	$\cdot 428$	$\cdot 1{,}58$,	$\cdot 158{,}585858$,
$\cdot 37{,}983$	$\cdot 379{,}839$,	$\cdot 32$,	$\cdot 323{,}232323$,
	$1\cdot 652{,}284$,		$1\cdot 503{,}026390$,

Note 1. Repeaters mixed with circulates are extended and added as circulates.

Note 2. Sometimes it is necessary to inspect two or more columns for ascertaining the carriage; because the carriage from a lower column will sometimes raise the sum of the higher, so as to alter the carriage from it to a new circle. This occurs in Ex. 2.

Note 3. The sum of the circles must be considered as a similar circle. If it consist entirely of ciphers, the amount is terminate. If all the figures be the same, the amount is a repeater. If they can be divided into parts exactly alike, the amount is a circle of fewer places; but, for the most part, the circle of the sum is similar to the extended circles.

To subtract circulating decimals. *Extend them till they become similar; and when you subtract the right-hand figure, consider whether* 1 *would have been borrowed if the circles had been extended farther, and make allowance accordingly.*

$\cdot 5{,}72$,	$\cdot 974$,	or $\cdot 974974$,	$\cdot 8{,}135$,	or $\cdot 8{,}135135$,
$\cdot 4{,}86$,	$\cdot 86$,	$\cdot 868686$,	$\cdot 452907$,	or $\cdot 4{,}529074$,
$\cdot 0{,}85$,		$\cdot 106288$,		$\cdot 3{,}606060$,
				or $\cdot 3{,}60$

SECT. III.—MULTIPLICATION OF INTERMINATE DECIMALS.

CASE I.—*When the multiplier is finite and the multiplicand repeats, carry by* 9 *when you multiply the repeating figure; the right-hand figure of each line of the product is a repeater, and they must be extended and added accordingly.*

Ex. $\cdot 1349\dot{4}$
$\cdot 367$
$9446\dot{1}$
$80966\dot{6}$
$404833\dot{3}$
$\cdot 0495246\dot{1}$

If the sum of the right-hand column be an even number of 9's, the product is finite; otherwise it is a repeater.

CASE II.—*When the multiplier is finite, and the multiplicand circulates, add to each product of the right-hand figure the carriage which would have been brought to it if the circle had been extended. Each line of the product is a circle similar to the multiplicand, and therefore they must be extended and added accordingly.*

The product is commonly a circulate similar to the

Decimal Fractions.

multiplicand; sometimes it circulates fewer places, repeats or becomes finite; it never circulates more places.

Ex. ·37,46, × ·235
·235
187,32,
1123,93,
7492,92,
·08804,19,

CASE III.—*When the multiplier repeats or circulates, find the product as in infinite multipliers, and place under it the products which would have arisen from the repeating or circulating figures if extended.*

Ex. 1*st*, ·958 × ·$\not{8}$
·8
7664|
766|4
76|64
7|664
|7664
·8515

2*d*, ·784 × ·36,
·36,
4704
2352
28224|
282|24
2|8224
285,09,

It is evident, that if a repeating multiplier be extended to any length, the product arising from each figure will be the same as the first, and each will stand one place to the right hand of the former. In like manner, if a circulating multiplier be extended, the product arising from each circle will be alike, and will stand as many places to the right hand of the former as there are figures in the circle. In the foregoing examples there are as many of these products repeated as is necessary for finding the total product. If we place down more, or extend them farther, it will only give a continuation of the repeaters or circulates.

The multiplication of interminate decimals may be often facilitated by reducing the multiplier to a vulgar fraction, and proceeding as directed p. 558, col. 2, par 8. Thus,

3*d*, ·3824 × ·$\not{7}$ = $\frac{7}{9}$
7
9)2·6768
·2974$\not{2}$

4*th*, ·384 × ·23, = $\frac{23}{90}$
23 2
1152 23
768
90)8·832
·0981$\not{3}$.

Therefore, in order to multiply by $\not{3}$, we take one third part of the multiplier; and, to multiply by $\not{6}$, we take two thirds of the same. Thus,

5*th*, ·784 × ·$\not{3}$ = $\frac{1}{3}$
3)·784
·261$\not{3}$

6*th*, ·8761 × ·$\not{6}$ = $\frac{2}{3}$
2
3)1·7522
·5840$\not{6}$

As the denominator of the vulgar fractions always consists of 8's or of 9's with ciphers annexed, we may use the contraction explained p. 549, col. 1, par 1, &c.; and this will lead us exactly to the same operation which was explained p. 564, col. 1, par. 1, &c. on the principles of decimal arithmetic.

7*th*, ·735 × ·326 = $\frac{323}{990}$
323 3
2205 323
1470
2205
99|0)237405
2374,05
23,74
,23
·239803,

8*th*, ·278 × ·365, = $\frac{365}{999}$
365
1390
1668
834
999)101470,
101,
·101,571,

When the multiplier is a mixed repeater or circulate, we may proceed as in *Ex.* 4*th* and 7*th*; or we may divide the multiplier into two parts, of which the first is finite, and the second a pure repeater or circulate, with ciphers prefixed, and multiply separately by these, and add the products.

Thus, ·384 × ·2$\not{5}$ or by ·2 = ·0768 and by ·05 = ·0213$\not{3}$
·09813

or thus, ·384
·2$\not{5}$
9)1920
213$\not{3}$
768
·0981$\not{3}$

In the following examples the multiplicand is a repeater, and therefore the multiplication by the numerator of the vulgar fraction is performed as directed p. 564, col. 1.

9*th*, ·68$\not{3}$ × $\not{5}$ = $\frac{5}{9}$
5
9)3·41$\not{6}$(·37,962,
27
71
63
*86
81
56
54
26
18
*86

10*th*, ·6$\not{3}$ × ·2,39 = $\frac{237}{990}$
·237 2
443 237
189$\not{9}$
1266$\not{6}$
99)15010(·15,16,
99
511
495
*160
99
610
594
*16

In the following examples the multiplicand is a circulate, and therefore the multiplication by the numerator is performed as directed, p. 563, col. 2, par *ult.*

11*th*, ·3,81· × ·5$\not{3}$ = $\frac{48}{90}$
48 5
3054 48
15272
9|0)183,27,(.203,63,
18
*032
27
57
54
*32

12*th*, ·12, × ·03, = $\frac{3}{99}$
3
99)36,36(·036730945821854912764,
666
723
306
936
453
576
813
216
183
846
543
486
903
126
273
756
633
396
*036

In *Ex.* 12 we have omitted the products of the divisor, and only marked down the remainders. These are found

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by adding the left-hand figure of the dividual to the remaining figures of the same. Thus, 363 is the first dividual, and 3, the left hand figure, added to 63, the remaining figures, gives 66 for the first remainder; and the second dividual, 666, is completed by annexing the circulating figure 6, the reason of which may be explained as follows. The highest place of each dividual shows, in this example, how many hundreds it contains; and as it must contain an equal number of ninety-nines, and also an equal number of units, it follows that these units, added to the lower places, must show how far the dividual exceeds that number of ninety-nines. The figure of the quotient is generally the same as the first place of the dividual, sometimes one more. This happens in the last step of the foregoing example, and is discovered when the remainder found, as here directed, would amount to 99 or upwards; and the excess above 99 only must in that case be taken to complete the next dividual.

14*th*, $\cdot 01, \times \cdot 01, = \frac{1}{99}$

```
      1
  ------
  99)·01(·000102030405060708091011121314151617181920
        (2122232425262728293031323334353637383940
        (4142434445464748495051525354555657585960
        (6162636465666768697071727374757677787980
        (81828384858687888990919293949596979899
```

The number of places in the circle of the product is sometimes very great, though there be few places in the factors; but it never exceeds the product of the denominator of the multiplier, multiplied by the number of places in the circle of the multiplicand. Therefore, if the multiplier be $\cancel{3}$ or $\cancel{6}$, the product may circulate three times as many places as the multiplicand; if the multiplier be any other repeater, nine times as many; if the multiplier be a circulate of two places, ninety-nine times as many: thus, in the last example, ·01, a circulate of two places, multiplied by ·01, a circulate of two places, produces a circulate of twice 99, or 198 places. And the reason of this limit may be inferred from the nature of the operation; for the greatest possible number of remainders, including 0, is equal to the divisor 99; and each remainder may afford two dividuals, if both the circulating figures, 3 and 6, occur to be annexed to it. If the multiplier circulate three places, the circle of the product, for a like reason, may extend 999 times as far as that of the multiplicand. But the number of places is often much less.

SECT. IV.—DIVISION OF INTERMINATE DECIMALS.

CASE I.—*When the dividend only is interminate, proceed as in common arithmetic; but when the figures of the dividend are exhausted, annex the repeating figure, or the circulating figures in their order, instead of ciphers, to the remainder.*

Ex. 1*st*, Divide ·5326 by ·7

```
·7)·532$(·76,095238,
   49
   --
    42
    42
    --
    *066
      63
      --
       36
       35
       --
        16
        14
        --
         26
         21
         --
          56
          56
          --
          *066
```

2*d*, Divide ·84$\cancel{3}$ by 5.

```
5)·84$(·168$
   5
   --
    34
    30
    --
     43
     40
     --
     *33
      30
      --
      *33
```

3*d*, Divide ·6532$ by 8.

```
8)·6532$(·08166$.
```

In these accounts the quotient is never finite. It may repeat if the dividend repeat; or, if the dividend circulate, it may circulate an equal number of places, often more, and never fewer. The greatest possible extent of the circle is found by multiplying the divisor into the number of places in the circle of the dividend. Thus, a circulate of 3 places, divided by 3, quotes a circulate of 3 times 3 or 9 places.

CASE II.—*When the divisor is interminate, the multiplications and subtractions must be performed according to the directions given for repeating and circulating decimals.*

Ex. 1*st*, Divide ·37845 by $\cancel{5}$.

```
$)·37845(·68121
   33333$
   ------
    4511$
    4444$
    -----
      67$
      55$
      ---
       11$
       111
       ---
         $
         $
         -
         0
```

2*d*, Divide ·245892 by 2·18

```
·2,18·)·245892(1·127005
       218181,81,
       ----------
        27710,18,
        21818,18,
        ---------
         5892,00,
         4363,63,
         -------
         1528,36,
         1527,2$,
         -------
           1090,90
           1090,90
           -------
                0
```

The foregoing method is the only one which properly depends on the principles of decimal arithmetic; but it is generally shorter to proceed by the following rule.

Reduce the divisor to a vulgar fraction, multiply the dividend by the denominator, and divide the product by the numerator.

Ex. 1*st*, Divide ·37845 by $\cancel{5} = \frac{5}{9}$.

```
          9
     ------
5)3·40605(·68121.
```

2*d*, Divide ·3784$\cancel{5}$ by $\cancel{6} = \frac{2}{3}$

```
          3
     ------
2)1·1353$(·56768$.
```

Note 1. Division by $\cancel{3}$ triples the dividend, and division by $\cancel{6}$ increases the dividend one half.

Note 2. When the divisor circulates, the denominator of the vulgar fraction consists of 9's, and the multiplication is sooner performed by the contraction explained p. 546, col. 1. It may be wrought in the same way when the divisor repeats, and the denominator of consequence is 9.

Note 3. If a repeating dividend be divided by a repeating or circulating divisor; or, if a circulating dividend be divided by a similar circulating divisor; or, if the number of places in the circle of the divisor be a multiple of the number in the dividend; then the product of the dividend multiplied by the denominator of the divisor will be terminate, since like figures are subtracted from like in the contracted multiplication, and consequently no remainder left.

Note 4. In other cases the original and multiplied dividend are similar, and the form of the quotient is the same as in the case of a finite divisor.

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Note 5. If the terms be similar, or extended till they become so, the quotient is the same as if they were finite, and the operation may be conducted accordingly; for the quotient of vulgar fractions that have the same denominator is equal to the quotient of their numerators.

Chap. XI.—Of the Extraction of Roots.

The origin of powers of involution has already been explained under the article Algebra. There now remains, therefore, only to give the most expeditious methods of extracting the square and cube roots; the reasons of which will readily appear from what is said under that article. As for all powers above the cube, unless such as are multiples of either the square or cube, the extraction of their roots admits of no deviation from the algebraic canon, which must be always constructed on purpose for them.

If the root of any power not exceeding the seventh power be a single digit, it may be obtained by inspection from the following Table of powers.

1st power or root.	2d power or square.	3d power or cube.	4th power or biquadrate.	5th power or sursolid.	6th power or cube squared.	7th power.
1	1	1	1	1	1	1
2	4	8	16	32	64	128
3	9	27	81	243	729	2187
4	16	64	256	1024	4096	16384
5	25	125	625	3125	15625	78125
6	36	216	1296	7776	46656	279936
7	49	343	2401	16807	117649	823543
8	64	512	4096	32768	262144	2097152
9	81	729	6561	59049	531441	4782969

Sect. I.—Extraction of the Square Root.

Rule I.—*Divide the given number into periods of two figures, beginning at the right hand in integers, and pointing toward the left. But in decimals begin at the place of hundreds, and point toward the right. Every period will give one figure in the root.*

II.—*Find by the table of powers, or by trial, the nearest lesser root of the left-hand period; place the figure so found in the quot; subtract its square from the said period, and to the remainder bring down the next period for a dividual or resolvend.*

III.—*Double the quot for the first part of the divisor; inquire how often this first part is contained in the whole resolvend, excluding the unit's place; and place the figure denoting the answer both in the quot and on the right of the first part; and you have the divisor complete.*

IV.—*Multiply the divisor, thus completed, by the figure put in the quot, subtract the produet from the resolvend, and to the remainder bring down the following period for a new resolvend, and then proceed as before.*

Note 1*st*, If the first part of the divisor, with unity supposed to be annexed to it, happen to be greater than the resolvend, in this case place 0 in the quot, and also on the right of the partial divisor; to the resolvend bring down another period; and proceed to divide as before.

Note 2*d*, If the product of the quotient figure into the divisor happen to be greater than the resolvend, you must go back and give a lesser figure to the quot.

Note 3*d*, If, after every period of the given number is brought down, there happen at last to be a remainder, you may continue the operation by annexing periods, or pairs of ciphers, till there be no remainder, or till the decimal part of the quot repeat or circulate, or till you think proper to limit it.

Extrac of Roo

Ex. 1*st*, Required the square root of 133225.

```
                 . . .
Square number 133225(365 root.          365
              9                         365
                                        ----
   1 div. 66)432 resolvend.            1825
             396 product.             2190
                                      1095
   2 div. 725) 3625 resolvend.        ------
               3625 product.          133225 proof.
```

2*d*, Required the square root of 72, to eight decimal places.

```
        . . . .
    72·00000000(8·48528137 root.
    64
   ----
 164)800
     656
    -----
1688)14400
     13504
    ------
16965)89600
      84825
     ------
169702)477500
       339404
     ------
169704)138096
  .... 135763
       ------
         2333
         1697
         ----
          636
          509
          ---
          127
          118
          ---
            9
```

After getting half of the decimal places, work by contracted division for the other half; and obtain them with the same accuracy as if the work had been at large.

3*d*, Required the square root of ·2916.

```
      . .
    ·2916(·54 root.
     25
    ----
  104)416
      416
      ---
```

If the square root of a vulgar fraction be required, find the root of the given numerator for a new numerator, and find the root of the given denominator for a new denominator. Thus the square root of $\frac{4}{9}$ is $\frac{2}{3}$, and the root of $\frac{16}{25}$ is $\frac{4}{5}$; and thus the root of $\frac{25}{4}$ $(= 6\frac{1}{4})$ is $\frac{5}{2} = 2\frac{1}{2}$.

But if the root of either the numerator or denominator cannot be extracted without a remainder, reduce the vulgar fraction to a decimal, and then extract the root, as in Ex. 3*d*, above.

Sect. II.—Extraction of the Cube Root.

Rule I.—*Divide the given number into periods of three figures, beginning at the right hand in integers, and pointing toward the left. But in decimals, begin at the place of thousands, and point toward the right. The number of periods shows the number of figures in the root.*

II.—*Find by the table of powers, or by trial, the nearest lesser root of the left-hand period; place the figure so found in the quot; subtract its cube from the said period; and to the remainder bring down the next period for a dividual or resolvend.*

The divisor consists of three parts, which may be found as follows:

III. *The first part of the divisor is found thus: Multiply the square of the quot by* 3, *and to the product annex two ciphers; then inquire how often this first part of the divisor is contained in the resolvend, and place the figure denoting the answer in the quot.*

IV. *Multiply the former quot by* 3, *and the product by the figure now put in the quot; to this last product annex a cipher, and you have the second part of the divisor. Again, square the figure now put in the quot for the third part of the divisor; place these three parts under one another as in addition, and their sum will be the divisor complete.*

V. *Multiply the divisor thus completed by the figure last put in the quot, subtract the product from the resolvend, and to the remainder bring down the following period for a new resolvend, and then proceed as before.*

Note 1. If the first part of the divisor happen to be equal to or greater than the resolvend, in this case place 0 in the quot, annex two ciphers to the said first part of the divisor, to the resolvend bring down another period, and proceed to divide as before.

Note 2. If the product of the quotient figure into the divisor happen to be greater than the resolvend, you must go back, and give a lesser figure to the quot.

Note 3. If, after every period of the given number is brought down, there happen at last to be a remainder, you may continue the operation by annexing periods of three ciphers till there be no remainder, or till you have as many decimal places in the root as you judge necessary.

Ex. 1*st*, Required the cube root of 12812904.

```
                  . .
Cube number 12812904(234 root.
                  8
                  ----
1st part 1200 }   )4812 resolvend.
2d part   180 }
3d part     9 }
1 divisor 1389 × 3=4167 product.
1st part 158700 }  )645904 resolvend.
2d part    2760 }
3d part      16 }
2 divisor 161476 × 4=645904 product.
```

Proof.

```
   234                    Square 54756
   234                           234
   ---                        ------
   936                        219024
  702                        164268
 468                        109512
Square 54756               Cube 12812904
```

Ex. 2*d*, Required the cube root of $28\frac{3}{4}$.

```
                  . . .
                  28·750000(3·06 root.
                  27
                  -------
270000 }          )1750000 resolvend.
  5400 }
    36 }
Divid. 275436 × 6=1652616 product.
                   97384 remainder.
```

Proof.

```
   3·06                Square 9·3636
   3·06                          3·06
   ----                       -------
   1836                        561816
  918                         280908
Square 9·3636               28·652616
                                97384 rem.
                            28·750000 cube.
```

If the cube root of a vulgar fraction be required, find the cube root of the given numerator for a new numerator, and the cube root of the given denominator for a new denominator. But if the root of either cannot be extracted without a remainder, reduce the vulgar fraction to a decimal, and then extract the root.

ARIUS, a divine of the fourth century, the head and founder of the Arians, a sect which denied the eternal divinity and substantiality of the Word, was born in Libya. Eusebius, bishop of Nicomedia, a great favourite of Constantia, sister of the emperor Constantine, and wife of Licinius, became a zealous promoter of Arianism. He took Arius under his protection, and introduced him to Constantia; so that the sect increased, and several bishops embraced it openly. In the cities, however, disputes arose so high, that the emperor was obliged to assemble a council—that of Nice—where, in the year 325, the doctrine of Arius was condemned, he himself banished by the emperor, all his books ordered to be burnt, and capital punishment denounced against whoever dared to keep them. After five years' banishment, he was recalled to Constantinople, where he presented the emperor with a confession of his faith, drawn up so artfully, that it fully satisfied him. Notwithstanding which, Athanasius, now advanced to the see of Alexandria, refused to admit him and his followers to communion. This so enraged them, that by their interest at court they procured the deposition and banishment of that prelate. But the church of Alexandria still refusing to admit Arius into their communion, the emperor sent for him to Constantinople, where, upon delivering in a fresh confession of his faith in terms less offensive, the emperor commanded Alexander, the bishop of that church, to receive him the next day into his communion; but that very evening Arius died suddenly. The heresy, however, did not expire with the heresiarch: his party continued still in great credit at court. Athanasius, indeed, was soon recalled from banishment, but as soon removed again; for the Arians, under the countenance of government, made and deposed bishops as it best served their purposes. In short, this sect shone with great lustre above 300 years. It was the reigning religion of Spain for above two centuries; it was on the throne both in the East and West; it prevailed in Italy, France, Pannonia, and Africa; and was not extirpated till about the end of the 8th century. It was afterwards set on foot in the West by Servetus. Erasmus seems to have aimed at reviving it in his Commentaries on the New Testament; and the learned Grotius appears to favour the doctrine.

ARK, Noah's, a floating vessel built by Noah, for the preservation of his family, and the several species of animals, during the deluge. The ark has afforded several points of curious inquiry relating to its form, capacity, materials, &c. The wood of which it was built is called in the Hebrew *gopher wood*, and in the Septuagint *square timbers*. Some translate the original *cedar*, others *pine*, others *box*, &c. Pelletier prefers cedar, on account of its incorruptibility and the great plenty of it in Asia. Fuller and Bochart contend that it was built of what the Greeks call κυπαρισσος, or the *cypress tree*; for, taking away the termination, *kupar* and *gopher* differ very little in sound. In what place Noah built and finished his ark is no less a matter of disputation; but the most general opinion is, that it was built in Chaldea, in the territories

of Babylon. Its dimensions, as given by Moses, are 300 cubits in length, 50 in breadth, and 30 in height; which some have thought too scanty, considering the number of things it was to contain; and hence an argument has been drawn against the authority of the relation. But Buteo and Kircher have shown geometrically, that, taking the common cubit of a foot and a half, the ark was sufficient for all the animals supposed to be lodged in it. Father Lamy contends that it was 110 feet longer than the church of St Mary at Paris, and 64 feet narrower; and Dr Arbuthnot computes it to have been 81,062 tons. It contained, besides eight persons of Noah's family, one pair of every species of unclean animals, and seven pair of every species of clean animals, with provisions for them all during the whole year. By the description Moses gives of the ark, it appears to have been divided into three stories, each ten cubits or 15 feet high; and it is agreed on, as most probable, that the lowest story was for the beasts, the middle for the food, and the upper for the birds, with Noah and his family.

Ark of the Covenant, a small chest or coffer, three feet nine inches in length, two feet three inches in breadth, and two feet three inches in height, in which were contained the golden pot that held manna, and Aaron's rod, and the tables of the covenant. This coffer was made of shittim-wood, and covered with a lid, which was made of solid gold. The ark was reposited in the holiest place of the tabernacle. It was taken by the Philistines, and detained 20, some say 40 years, at Kirjath-jearim; but the people being afflicted with emerods on account of it, returned it with divers presents. It was afterwards placed in the temple. The lid or covering of the ark was called the *propitiatory* or *mercy-seat;* over which were two figures placed called *cherubims*, with expanded wings of a peculiar form. Here the Schechinah rested both in the tabernacle and temple in a visible cloud, hence were issued the Divine oracles by an audible voice; and the high priest appeared before this mercy-seat once every year, on the great day of expiation; and the Jews, wherever they worshipped, turned their faces towards the place where the ark stood. In the second temple there was also an ark, made of the same shape and dimensions with the first, and put in the same place, but without any of its contents and peculiar honours. It was used as a representative of the former on the day of expiation, and as a repository of the original copy of the Holy Scriptures, collected by Ezra and the men of the great synagogue, after the captivity.

ARKLOW, a seaport town of Ireland, in the county of Wicklow, situated on the south side of the river Avoca or Ovoca, near the Irish Sea. The river is crossed by a bridge of 19 arches, and its harbour admits small vessels. It contains a charter-school for 50 girls; and there are barracks at its western extremity. It was assailed in 1798 by a body of insurgents, and suffered considerable damage, though they were finally dispersed. Population 3808. 17 miles S. from Wicklow, and 49 S. E. from Dublin. Long. 6. 0. W. Lat. 52. 48. N.

ARKWRIGHT, Sir Richard, famous for his inventions in cotton spinning, was born at Preston in Lancashire, in 1732, of parents in humble circumstances. He was the youngest of thirteen children, received but a very indifferent education, and was bred to the trade of a barber. But the *res angusta domi* could not repress the native vigour of his mind, or extinguish the desire he felt to emerge from his low situation. In the year 1760 he had established himself in Bolton-le-Moor, where he exchanged the trade of a barber for that of an itinerant hair-merchant; and having discovered a valuable chemical process for dying hair, he was in consequence enabled to amass a little property. It is unfortunate that very little is known of the steps by which he was led to those inventions that raised him to distinction, and have immortalized his name. His residence in a district where a considerable manufacture of linen goods, and of linen and cotton mixed, was carried on, must have given him ample opportunities of becoming acquainted with the various processes that were in use in the cotton manufacture, and of the attempts that had been made and were then making to improve them. His attention was thus naturally drawn to this peculiar department; and, while he saw reason to conclude that it was likely to prove the most advantageous in which he could engage, he had sagacity and good fortune to invent and improve those extraordinary machines by which, unlike most inventors, he amassed vast wealth, at the same time that he added prodigiously to the demand for labour, and to the riches and comfort of the civilized world.

The *spinning-jenny*, invented in 1767 by Hargraves, a carpenter at Blackburn in Lancashire, gave the means of spinning twenty or thirty threads at once with no more labour than had previously been required to spin a single thread. The thread spun by the jenny could not, however, be used, except as weft, being destitute of the firmness or hardness required in the longitudinal threads or warp. But Mr Arkwright supplied this deficiency by the invention of the *spinning-frame*—that wonderful piece of machinery, which spins a vast number of threads of any degree of fineness and hardness, leaving to man merely to feed the machine with cotton, and to join the threads when they happen to break. It is not difficult to understand the principle on which this machine is constructed, and the mode of its operation. It consists of two pairs of rollers, turned by means of machinery. The lower roller of each pair is furrowed or fluted longitudinally, and the upper one is covered with leather, to make them take a hold of the cotton. If there were only one pair of rollers, it is clear that a carding of cotton, passed between them, would be drawn forward by the revolution of the rollers; but it would merely undergo a certain degree of compression from their action. No sooner, however, has the carding, or *roving* as it is technically termed, begun to pass through the first pair of rollers, than it is received by the second pair, which are made to revolve with (as the case may be) three, four, or five times the velocity of the first pair. By this admirable contrivance, the roving is drawn out into a thread of the desired degree of tenuity, a twist being given to it by the adaptation of the spindle and fly of the common flax wheel to the machinery.

Such is the principle on which Mr Arkwright constructed his famous spinning-frame. It is obvious that it is radically different from the previous methods of spinning either by the common hand-wheel or distaff, or by the jenny, which is only a modification of the common wheel. Spinning by rollers was an entirely original idea; and it is difficult to determine which is most worthy of admiration—the genius which led to so great a discovery, or the consummate skill and address by which it was so speedily perfected and reduced to practice. Mr Arkwright stated that he accidentally derived the first hint of his great invention from seeing a red-hot iron bar elongated by being made to pass between rollers;[1] and though

[1] See the account of Mr Arkwright, in the article Derbyshire, in the *Beauties of England and Wales*, vol. iii. p. 518. The statements in this account are of the highest authority, inasmuch as we have reason to believe it was furnished by Mr Strutt, the son of Mr Arkwright's first partner.

there is no mechanical analogy between that operation and his process of spinning, it is not difficult to imagine, that by reflecting upon it, and placing the subject in different points of view, it might lead him to his invention. The precise era of the discovery is not known; but it is most probable that the felicitous idea of spinning by rollers had occurred to his mind as early as the period when Hargraves was engaged in the invention of the jenny, or almost immediately after. Not being himself a practical mechanic, Arkwright employed a person of the name of John Kay, a watchmaker at Warrington, to whom we shall afterwards have to refer, to assist him in the preparation of the parts of his machine. Having made some progress towards the completion of his inventions, he applied in 1767 to Mr Atherton of Liverpool for pecuniary assistance to enable him to carry them into effect; but this gentleman declined embarking his property in what appeared so hazardous a speculation, though he is said to have sent him some workmen to assist in the construction of his machine; the first model of which was set up in the parlour of the house belonging to the free grammar school at Preston.

His inventions being at length brought into a pretty advanced state, Arkwright, accompanied by Kay, and a Mr Smalley of Preston, removed to Nottingham in 1768, in order to avoid the attacks of the same lawless rabble that had driven Hargraves out of Lancashire. Here his operations were at first greatly fettered by a want of capital. But Mr Strutt[1] of Derby, a gentleman of great mechanical skill, and largely engaged in the stocking manufacture, having seen Arkwright's inventions, and satisfied himself of their extraordinary value, immediately entered, conjointly with his partner Mr Need, into partnership with him. The command of the necessary funds being thus obtained, Mr Arkwright erected his first mill, which was driven by horses, at Nottingham, and took out a patent for spinning by rollers, in 1769. But as the mode of working the machinery by horse-power was found too expensive, he built a second factory, on a much larger scale, at Cromford in Derbyshire, in 1771, the machinery of which was turned by a water-wheel, after the manner of the famous silk-mill erected by Sir Thomas Lombe. Having made several additional discoveries and improvements in the processes of carding, roving, and spinning, he took out a fresh patent for the whole in 1775; and thus completed a series of machinery so various and complicated, yet so admirably combined, and well adapted to produce the intended effect, in its most perfect form, as to excite the astonishment and admiration of every one capable of appreciating the ingenuity displayed and the difficulties overcome.[2]

When the vast importance of these discoveries became known, it is not surprising that every effort should have been made to have the patents set aside, and Mr Arkwright deprived of the profit and honour to be derived from them. But after a pretty attentive consideration of the various proceedings relative to this subject, we have no hesitation in saying, that we see no good grounds for crediting the statement made in the court of king's bench in 1785, and recently repeated by Mr Guest in his work on the cotton manufacture, which ascribes the invention of spinning by rollers to Highs or Hayes, from whom Arkwright is said to have learned it; and we shall now briefly state our reasons for holding this opinion.

Mr Arkwright's *first* patent for spinning by rollers, which is by far the most important, or rather, indeed, the essential part of his inventions, was obtained, as we have previously stated, in 1769; and its value and importance were no longer doubtful after the establishment of the factory at Cromford in 1771. The success which attended this novel method of spinning naturally excited the strongest desire on the part of the Lancashire manufacturers to participate in the advantages to be derived from it; and the fair presumption is, that instead of attempting clandestinely to pirate the invention, they would, had they conceived there were any good grounds to go upon, have at once contested the validity of the patent. But no such attempt was made till 1781, *twelve* years after the date of the first patent, and *six* years after the date of the second. And, even at that late period, Mr Arkwright's opponents came forward only in consequence of his having resolved to vindicate his rights, which had begun to be invaded on all sides, by raising an action against Colonel Mordaunt for an infringement of his patent. Mordaunt was supported by a combination of manufacturers; and, as they felt the question to be of the greatest importance, it is all but impossible to suppose that any thing would be omitted on their part which was conceived likely to contribute to their success. The case having been tried in the court of king's bench, after Trinity term, July 1781, the decision was unfavourable to Mr Arkwright. But it is of importance to observe, that no attempt was made at the trial to charge him with having purloined the inventions of others, and that the verdict was given on the sole ground of the *description of the machinery in the specification being obscure and indistinct.* Mr Arkwright admitted that such was partly the case; adding, however, that the obscurity charged against the specification had been intended only to prevent foreigners from pirating his inventions. On any other principle, indeed, his conduct would be inexplicable; for, as his inventions were fully known to hundreds of workmen in his own employment, and as he had sold the privilege of using them to great numbers of individuals in different parts of the country, it is impossible to suppose that he could either have expected or intended to conceal his inventions after the expiration of his patent.[3] In consequence of the result of this trial, Mr Arkwright and his partners prepared a *Case*, setting forth the value of the inventions, and the circumstances which had led to the indistinctness complained of in the specification, which they at one time intended to lay before parliament, as the foundation of an application for an act for their relief. But this intention was subsequently abandoned; and in a new trial (Arkwright *v.* Nightingale), which took place in the court of common pleas on the 17th of February 1785, Lord Loughborough, the presiding judge, having expressed himself favourably with respect to the sufficiency

[1] This was the justly celebrated Mr Jedediah Strutt. He was the son of a farmer, and was born in 1726. His father paid little attention to his education; but, under every disadvantage, he acquired an extensive knowledge of science and literature. He was the first individual who succeeded in adapting the stocking-frame to the manufacture of *ribbed* stockings. The manufacture of these stockings, which he established at Derby, was conducted on a very large scale, first by himself and his partner Mr Need, and subsequently by his sons, until about 1805, when they withdrew from this branch of business.

[2] See the *Case* of Richard Arkwright & Co. in 1782; the account of Sir Richard Arkwright in Aikin's *Biographical Dictionary*; the *History, Gazetteer, &c. of Lancashire*, by Edward Baines, vol. ii. p. 484, &c.

[3] It was erroneously stated, in an article in the *Edinburgh Review* (No. 91), from which this sketch is principally abstracted, on the authority of the article "Cotton Manufacture," in the Supplement to this work (vol. iii. p. 394), that a trial had been instituted in 1772, in which Mr Arkwright proved successful, to have the original patent set aside. But the first trial did not really take place, as above stated, till 1781.

of the specification, a verdict was given for Mr Arkwright. On this, as on the former trial, nothing was stated against the originality of the invention.

In consequence of these conflicting verdicts, the whole matter was brought, by a writ of *scire facias*, before the court of king's bench, to have the validity of the patent finally settled. And it was not till this third trial, which took place before Mr Justice Buller and a special jury, on the 25th of June 1785, that Mr Arkwright's claim to the inventions which formed the subject of the patent was disputed. To support this new allegation, Mr Arkwright's opponents brought forward, for the first time, Highs or Hayes, a reed-maker at Bolton. He stated that he had invented a machine for spinning by rollers previously to 1768; that he had employed the watchmaker Kay, to whom we have already referred, to make a model of that machine; and Kay was produced to prove that he had communicated that model to Mr Arkwright, and that that was the real source of all his pretended inventions. Having no idea that any attempt was to be made at so late a period to overturn the patent on this new ground, Mr Arkwright's counsel were not prepared with evidence to repel this statement; but it was stated by Mr Sergeant Adair, on a motion for a new trial on the 10th of November of the same year, that he was furnished with affidavits contradicting, in the most pointed manner, the evidence that had been given by Kay and others with respect to the originality of the invention. The court, however, refused to grant a new trial, on the ground, that whatever might be the fact as to the question of originality, the deficiency in the specification was enough to sustain the verdict.

But, independently altogether of the statements made on the motion for a new trial, the improbability of the story told by Highs and Kay seems glaring and obvious. Highs states in his evidence that he had accused Arkwright of getting possession of his invention by means of Kay so early as 1769, or about that period. Where, then, it may be asked, was this Mr Highs ever since that period, and particularly during the first trial in July 1781, and the second in February 1785? Living in Lancashire, associating with manufacturers, and in the habit, as he declares in his evidence, of making machines for them, he could not fail to be speedily informed with respect to the vast importance and value of the invention Mr Arkwright had purloined from him. It is impossible but he must have been acquainted with the efforts that were making by the Lancashire manufacturers to set aside the patents; and is it to be supposed, had he really been the inventor, that he would have remained for *sixteen* years a passive spectator of what was going forward? that he would have allowed Mr Arkwright to accumulate a princely fortune by means of *his* inventions, while he remained in a state of poverty? or that he would have withheld his evidence when the manufacturers attempted to wrest from Mr Arkwright what he had so unjustly appropriated? A single hint from Highs or Kay would, had their story been well founded, have sufficed to force Mr Arkwright to give them a share of his profits, or would have furnished the manufacturers with the means they were so anxious to obtain, of procuring the immediate dissolution of the patents. But it has never been alleged that Mr Arkwright took any pains to conciliate these persons: on the contrary, he treated Highs with the most perfect indifference, and not only dismissed Kay from his service, but even threatened to prosecute him on a charge of felony. And can any one imagine for a moment, that persons with so many and such overpowering temptations to speak out, and with no inducement of any sort to be silent, should have gone about for more than twice the period of a Pythagorean noviciate, with so important a secret closely pent up in their bosoms? We confess that such a supposition seems to us altogether absurd and incredible; and we believe our readers will agree with us in thinking, that it is infinitely more consistent with probability to suppose that the story of Highs and Kay had been manufactured for the occasion, than that it was really true.

The improbability of the statements made on this subject by Guest, in his *History of the Cotton Manufacture*, appear still more obvious, from his attributing to Highs the invention, not only of the spinning frame, but also of the jenny, which had been universally ascribed to Hargraves. But no weight can be attached to such rash and ill-considered statements. It would be next to a miracle, had two methods of spinning, both very ingenious, but radically different in their first principles, been invented nearly at the same time by the same individual.

It appears, from a communication from Mr Charles Wyatt to his brother, in the *Repertory of Arts* for 1817, and which has been reprinted by Mr Kennedy, in an interesting article on the Rise and Progress of the Cotton Trade, in the *Manchester Memoirs* (2d series, vol. iii. p. 135), as well as from the distinct reference to them in the *Case* printed by Mr Arkwright in 1782, that attempts had been made in the early part of last century to spin cotton by means of machinery. But these attempts proved ruinous to the parties by whom they were made; and all knowledge of the machinery by which they attempted to effect their purpose has been long since lost. Mr Kennedy says he had seen a specimen of yarn spun about 1741, by the late Mr Wyatt of Birmingham; but he expresses his opinion that no competent judge would say that it was spun by a similar machine to that of Mr Arkwright. It was not indeed alleged at any of the trials that took place with respect to the validity of his patent, nor has it ever been alleged since, that he had borrowed anything whatever from these remote attempts. If he was really indebted to them, it must have been merely for the knowledge of the fact that such attempts had been made; and this might have stimulated him to turn his attention to the subject.

We have access to know that none of Mr Arkwright's most intimate friends, and who were best acquainted with his character, ever had the slightest doubt with respect to the originality of his invention. Some of them, indeed, could speak to the circumstances from their own personal knowledge; and their testimony was uniform and consistent. Such also seems to be the opinion now generally entertained among the principal manufacturers of Manchester. In proof of this, we may again refer to Mr Kennedy's valuable paper in the *Manchester Memoirs*. Mr Kennedy is one of the most eminent and intelligent cotton manufacturers in the empire, and it is of importance to remark, that, although he was resident in Manchester in 1785, when the last trial for setting aside Mr Arkwright's patent took place, and must, therefore, have been well acquainted with all the circumstances connected with it, he does not insinuate the smallest doubt as to his being the real inventor of the spinning frame, nor even so much as once alludes to Highs.

On their first introduction, Mr Arkwright's machines were reckoned by the lower classes as even more adverse to their interests than those of Hargraves; and reiterated attacks were made on the factories built for them.[1] But

[1] Dorning Rasbotham, Esq. a magistrate near Bolton, printed, some time about the period referred to, a sensible address to the weavers and spinners, in which he endeavoured to convince them that it was for their interest to encourage inventions for abridging

Arkwright. how extraordinary soever it may appear, it was amongst the manufacturers that the greatest animosity existed against Mr Arkwright; and it required all the prudence for which he was so remarkable to enable him to triumph over the powerful combination that was formed against him. At the outset of the business, they unanimously refused to purchase his yarn; and when his partners, Messrs Strutt and Need, had commenced a manufacture of calicoes, the manufacturers strenuously opposed a bill to exempt calicoes from a discriminating duty of 3d a yard laid on them, over and above the ordinary duty of 3d by an old act of parliament. Luckily, however, the manufacturers failed of their object; and, in 1774, an act of parliament was obtained (14th Geo. III. cap. 72), for the encouragement of the cotton manufacture, in which fabrics made of cotton are declared to have been *lately* introduced, and are allowed to be used as "a lawful and laudable manufacture;" the duty of 6d the square yard on such cottons as are printed or stained being at the same time reduced to 3d. But this disgraceful spirit of animosity, which must, had it been successful, have proved as injurious to the interests of the manufacturers as to those of Mr Arkwright, did not content itself with actions in the courts of law, or a factious opposition to useful measures in parliament, but displayed itself in a still more striking and unjustifiable manner; for it is a fact, that a large factory, erected by Mr Arkwright at Birkacre, near Chorley, in Lancashire, was destroyed by a mob collected from the adjacent country, in the presence of a powerful body of police and military, without any one of the civil authorities requiring them to interfere to prevent so scandalous an outrage.

Fortunately, however, not for himself only, but for his country and the world, every corner of which has been benefited by his inventions, Mr Arkwright triumphed over every opposition. The same ingenuity, skill, and good sense, which had originally enabled him to invent his machine and get it introduced, enabled him to overcome the various combinations and difficulties with which he had subsequently to contend.

Though a man of great personal strength, which he is said to have displayed when young, in election riots at Preston, Mr Arkwright never enjoyed good health. During the whole of his splendid and ever memorable career of invention and discovery, he was labouring under a very severe asthmatic affection. A complication of disorders at length terminated his truly useful life in 1792, at his works at Cromford, in the sixtieth year of his age. He was high sheriff of Derbyshire in 1786; and, having presented a congratulatory address from the wapentake of Wirksworth to his majesty George III., on his escape from the attempt on his life by Margaret Nicholson, received the honour of knighthood. No man ever better deserved his good fortune, or has a stronger claim on the respect and gratitude of posterity. His inventions have opened a new and boundless field of employment; and while they have conferred infinitely more real benefit on his native country than she could have derived from the absolute dominion of Mexico and Peru, they have been *universally* productive of wealth and enjoyments.

"The originality and comprehensiveness of Sir Richard Arkwright's mind," says Mr Bannatyne, "was perhaps marked by nothing more strongly than the judgment with which, although new to business, he conducted the great concerns his discovery gave rise to, and the systematic order and arrangement which he introduced into every department of his extensive works. His plans of management, which must have been entirely his own, as no establishment of a similar nature then existed, were universally adopted by others; and, after long experience, they have not yet, in any material point, been altered or improved."

Mr Arkwright was twice married. By his first marriage he had a son, the present Richard Arkwright, Esq. of Willersley Castle, near Cromford; by his second marriage he had a daughter, now Mrs Charles Hurt of Wirksworth, Derbyshire. Both have numerous descendants. (c. c.)

Arles || Armagh.

ARLES, an arrondissement in the department of the mouths of the Rhone, in France, extending over 883 square miles, or 585,120 acres. It is divided into eight cantons, and subdivided into 33 communes, which contain 70,641 inhabitants.

ARLES, a city, the chief of the arrondissement of the same name, in France. It is situated on the left bank of the principal branch of the Rhone, called the *Grand Rhone*, to avoid the bad navigation of which, a broad and deep canal to the harbour of Boue has been constructed. The surrounding country is fruitful, especially in corn. The city is ancient, large, and well built, containing, besides a cathedral and several churches, a fine town-house, an exchange, and other public buildings, and 20,151 inhabitants. Having been formerly a Roman colonial city, Arles abounds with many interesting remains of that people. The most remarkable are, an amphitheatre of 1000 feet in circumference, though its arena is filled with miserable dwellings; five arches of Roland's Tower; the remains of the palace of Constantine the Great, called *Le Chateau de Trouille;* the obelisk of granite before the town-house, 61 feet in height; and the Elysian fields, an ancient burial place, with many sarcophagi. It is in long. 5. 42. 27. E. Lat. 43. 40. 28. N.

ARMADA, a Spanish term, signifying a fleet of men of war. The armada which attempted to invade England in the time of Queen Elizabeth is famous in history. See ENGLAND.

ARMADILLO, in *Zoology*. See MAMMALIA *Index*.

ARMAGEDDON, a place spoken of in the Revelation (xvi. 16), which literally signifies the mountain of Mageddon or Megiddo, a city situated in the great plain at the foot of Mount Carmel, where King Josiah received his mortal wound in the battle against Necho, king of Egypt.

ARMAGH, an inland county in the province of Ulster, in Ireland, is bounded on the north by Lough Neagh, on the east by the county of Down, on the south-east by that of Louth, on the south-west by that of Monaghan, and on the west by the county of Tyrone. According to Ptolemy, it was inhabited by the Vinderii and Voluntii. It afterwards formed part of a territory called Orgial or Uriel, which also extended over Louth, Monaghan, and some smaller districts. It was likewise subdivided into the tracts or countries of Clanbrassil, the M'Cahans or M'Canes, Oirthir or Orior, the O'Hanlons, the Fews, and Hy Niellan. In the reign of James I. it was made shire ground, under its present name. It is now divided into the eight baronies of Armagh, Upper Fews, Lower Fews, O'Neilland East, O'Neilland West, Upper Orior, Lower

Boundaries. Ancient names. Divisions.

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labour. The result has shown the soundness of Mr Rasbotham's opinion. It is doubtful whether 30,000 persons were employed in all the branches of the cotton manufacture in 1767; whereas, in consequence of those very inventions which the workmen endeavoured to destroy, there are now upwards of 1,000,000 directly engaged in its different departments! There is, in fact, no idea so groundless and absurd as that which supposes that an increased facility of production can, under any circumstances, be injurious to the labourers.

Armagh. Extent.

Orior, and Turaney. The superficies of the county has been estimated at 293,919 acres, or nearly 458 square miles.

Ecclesiastical arrangements.

Considered in its ecclesiastical relations, it forms part of the archiepiscopal province of Armagh, which comprises the dioceses of Armagh, Clogher, Meath, Down, Connor, Derry, Raphoe, Kilmore, Dromore, and Ardagh. The archbishopric of Armagh extends over 468,500 acres, in the counties of Armagh, Londonderry, Tyrone, Louth, and Meath. It contains 111 parishes, consolidated into 80 benefices, having 78 churches, 75 glebe houses, and 16,324 acres of glebe, which, if equally apportioned among the incumbents, would give an average of 204 acres to each. Of these benefices the king presents to 4; the archbishop to 43; other dignitaries of the diocese to 14; laymen to 11; Trinity college, Dublin, to 4; St Patrick's cathedral, Dublin, to one; besides which, there are two joint presentations, and one disputed. The tithe paid by 48 of these parishes, which have conformed to the provisions of the tithe composition act, amounts to L.19,292, being at the rate of L.402 annually to each parish. If the aggregate of the tithe of those which have not yet compounded bear the same proportion to the number of parishes as those which have, the total tithe of the diocese would amount to L.44,613, which, divided among the 80 incumbents, would afford an income to each of L.557 per annum, independently of glebes, manses, or occasional dues. The archbishop's income, derived from lands, is estimated at L.22,000 per annum.

Parishes. Tithe. Archbishop's income.

Population.

The county of Armagh contains 22 entire parishes, and 5 parts of parishes, the remainder of which are in some of the adjoining counties. The total population, according to the last census, taken in 1821, amounts to 197,427 souls, being at the rate of one individual to every acre and a half, or one family to every eight acres. Of this population, 28,905 are stated in the same census to be employed in agriculture, 67,182 in trade, manufactures, and commerce, and 14,521 in other occupations, leaving 86,819 of both sexes and of every age unoccupied.

The county of Armagh returns three members to the imperial parliament,—two for the county at large, and one for the city. The election for the county is vested, as in all the other counties of Ireland, in the freeholders, whose number, previously to the passing of the Catholic Relief Bill in 1829, amounted to 8746,—a large number for a county, one of the smallest in superficial extent. These were classed as follows,—203 freeholders holding tenures of L.50 value; 124 of those of L.20; and 8419 of those of L.2, or, as they are more commonly called, forty shilling freeholders. The abolition of the last-named class, which took place at the period just mentioned, reduced the number of electors to 1361, viz. 235 freeholders of L.50; 186 of L.20; and 940 of L.10, which is now the lowest value of a tenure entitling a freeholder to vote.

Soil.

The nature of the soil, and the general character of the land, are well adapted for agricultural purposes. Hills of gentle ascent, of pleasing forms and various altitudes, diversify the surface. Large tracts, particularly in the vicinity of Armagh city, and thence throughout the northern parts, are covered with a stratum of rich productive soil: many of these are well adapted for the culture of wheat, being composed of a strong clay resting on a substratum of excellent limestone. The southern and western parts rise into a rugged, and in many parts a barren elevation, known by the name of the Fews Mountains. The highest of these mountains, and the second in height in the province, is named Slieve-Gallien. Its top is crowned by a large cairn or pile of stones, which forms the roof of a singular cavern of artificial construction, seemingly intended for other than sepulchral purposes. Two lower ranges, named the Newry and Fathom Mountains, lie nearer the sea.

Mountains.

Indications of lead show themselves in several parts; traces of deserted mines of this mineral have also been discovered, but none are now wrought. Marble of good quality and some beauty is raised in large quantities near the city of Armagh. A blue stone, well adapted for building, is common in many places. The steatite or soap-stone has also been found; as likewise good potters' earth, brilliant cubic pyrites, and ironstone of very rich quality. Chalybeate springs in several parts point out the existence of iron; but this mineral has not been found in sufficient quantities to justify the outlay of money towards raising it. Pearls, the production of a species of shell-fish between the oyster and the muscle, have been found in the river Bann.

Minerals.

The county is well watered by numerous streams; the principal are the Callen, the Tynan, and the Tallwater, which fall into the Blackwater, a river that, after forming part of the boundary between this county and Tyrone, empties itself into the south-western angle of Lough Neagh. The Tara, the Newtoun Hamilton, the Creggan, and the Fleury, flow into the Bay of Dundalk. The Cam or Camlin joins the Bann, which, rising in the Mourne Mountains, in the southern extremity of the county of Down, forms part of the western boundary of Armagh county, and falls into Lough Neagh to the east of the Blackwater. With the aid of a canal, the Bann is navigable for vessels of sixty tons burden through part of its course.

Rivers.

Lough Neagh, which stretches along the north of Armagh, is confined by it and the four counties of Down, Londonderry, Antrim, and Tyrone. It is of an oblong form, and is computed to cover 94,274 acres. Seven rivers and a number of smaller streams flow into it, while the only vent for its accumulated waters is through the channel of the northern Bann. Though estimable as a means of water communication through an extensive tract of country, it has little of the picturesque or romantic to attract attention. Ram Island, near the Antrim shore, and Derrywarragh, near the mouth of the Blackwater, are its only islands. Some parts of its shores have long been celebrated for the petrifying qualities of its waters. The cause of this phenomenon is not satisfactorily ascertained; for, though logs and branches of trees, in various stages of the petrifactive process, have been found, this effect has not been produced on any pieces of timber laid there for the sake of experiment. Camlough and Lough Clay, the only lakes within the county, are of small dimensions.

Lakes.

Tillage cannot be said to be either in a very advanced or a very backward state. Farm manure is much used, but lime still more; which latter, though abundant in some parts of the county, is so scarce in others that it is drawn eight or ten miles for the purposes of tillage. It is chiefly burned with turf raised from bogs dispersed throughout most districts, but chiefly in the northern parts, where they are of fine quality and large dimensions. Fifty barrels of lime are allowed to the Irish acre. The chief succession of crops is oats repeated two or three seasons after potatoes or wheat, with manure. Green crops are every year more attended to, particularly among the wealthier farmers, and the gentry, who hold land in their own hands, and thus give a tone and example to the country for agricultural improvements.

Agriculture.

The farms are in general very small, yet their owners are generally in circumstances of comparative comfort. There are few who do not keep at least one cow, or a few sheep; none but the poorest cottar is without a pig. Their usual diet is oatmeal, potatoes, and milk porridge, varied sometimes by salt herrings. The better description of farmers use animal food, chiefly bacon and poultry.

Size of farms.

Armagh. Cheese in small quantity, and butter more than sufficient for domestic use, are obtained from their cows. Their sheep furnish wool, which is manufactured into the coarse cloths, blankets, and druggets, used by themselves and their families.

Linen manufacture. The manufacture to which the industry of the country is chiefly directed, and which has given a peculiar tone to the character of the population, is the linen. It is noways necessary to the promotion of this manufacture, that the spinners and weavers should be congregated in large towns, or united in crowded and unwholesome factories. On the contrary, most of its branches can be carried on in the cottages of the peasantry. The men devote to the loom those hours which are not required for the cultivation of their little farms; the women spin and reel the yarn during the intervals of their other domestic occupations. Every female servant is bound to produce a certain quantity of yarn weekly, in addition to her other duties. Smooth lawns, perennial streams, pure springs, and the open face of heaven, are necessary for perfecting the bleaching process. Hence the extensive bleachers, with all their assistants and machinery, dwell in the country. Such is the effect of this combination of agricultural occupations with domestic manufactures, that the farmers are more than competent to supply the resident population of the county with vegetable, though not with animal food; and some of the less crowded and less productive parts of Ulster receive a considerable supply of oats, barley, and flour from it. Apples are grown in such quantities as to entitle the county to the epithet bestowed on it, of the orchard of Ireland.

Manners. The cause now dwelt upon has had an effect equally striking on the manners and appearance of the people. The men are stout and well proportioned; nor does it appear that their growth is checked or their general health deteriorated by their early application to the sedentary and stooping labour of the loom. The women are generally handsome, and, in consequence of being chiefly employed within doors, fairer than those of other districts.

Dress. On Sundays, and at fairs and similar places of resort, the dress and manners of both sexes indicate a superior degree of civilization. The interior of their cottages is neat, the exterior and the appendages cleanly.

Amusements. Cockfighting was once a favourite amusement among them, but the taste for it is rapidly declining. They delight in dancing, and have frequent meetings for the enjoyment of it; but hunting seems above all to be their darling recreation. The moment the cry of the hounds is heard, the labourer drops his spade, the weaver rushes from his loom, and the chase is followed with ardour and activity almost incredible; yet it rarely happens that redoubled exertions at their employments do not compensate for the time thus lost.

Character. Lively gratitude for favours, and a quick sense of injury or insult, yet seldom tinctured with feelings of revenge, are leading characteristics of their moral temperament.

Religion. In the towns and level parts of the county the protestant religion, in its two principal forms of the established church and the presbyterian discipline, predominates; but the Roman catholic is prevalent in the mountainous and less cultivated parts. As far as may be conjectured from the returns of the commissioners of education, the Roman catholics appear to constitute nearly one half of the gross population.

Education. According to those returns, the number of children at school in 1824 amounted to 13,800. If the total number of children between five and fifteen years of age, which may be called the period of education, be 49,000, as stated in the population returns of 1821, upwards of two thirds of the whole remain uninstructed. The religious persuasions of those educated are as follows:—Established church 4655, presbyterians 2864, other dissenters 511, Roman catholics 5281. The number of schools is 333, of which 264, containing 9151 students, are supported wholly by the fees of the pupils; the remaining 69 are maintained either by grants of public money or by the voluntary contributions of the wealthier classes; viz. 44 schools, educating 3153 pupils, are supported by the former means, and 25 schools, educating 1540 pupils, by the latter.

Towns. The population, as may be inferred from the preceding statements, is chiefly rural. The county can boast but of four towns of more than 1000 inhabitants each, viz. Armagh city 8493; Lurgan 2715; part of Newry, the other and more populous part being in the county of Down, 2543; and Tanderagee 1158: total population of the larger towns 14,909. That of the remaining towns and villages, 17 in number, amounts but to 6987 souls; the rural population, therefore, is 175,431, being nearly in the ratio of 12 to 1 with respect to that of the larger towns, and of 8 to 1 with respect to that of the towns and villages of every description.

Armagh city. The city of Armagh is 82 miles north of Dublin, being in 54° 20′ 55″ N. lat., and in 6° 37′ 57″ W. long. Though now much reduced in population, it was once considered as the metropolis of the island, and second only to Dublin in the number of its inhabitants. The honour of being its founder is attributed to St Patrick. It was built on an eminence named Druimsailech, or the Hill of Willows; its present name is supposed to be a slight corruption of Ardmacha, the High Place or Field. In 448 a synod was held here, the canons of which are still in existence. During the period anterior to the arrival of the English in Ireland, it suffered extremely from the assaults of the Danes, by whom it was repeatedly plundered and burnt. Nor was its condition much bettered by the change of masters. De Courcy, FitzAdelm, and De Lacy, pillaged it in turn in their attempts to subdue Ulster; and it was exposed to similar calamities during the wars by which the north of Ireland was desolated in the reign of Elizabeth. Her successor, James I., granted it a charter, according to which it has since been governed. Its decline was still farther increased by the non-residence of the archbishops, who, in consequence of the unsettled state of the northern province, fixed their residence for many years at Drogheda. From this deplorable state it was raised by Lord Rokeby, better known by the name of Primate Robinson. When he determined to make it the seat of his permanent residence, this venerable city was little more than a collection of cabins.

Public buildings. He erected in it an archiepiscopal palace, a college or grammar school for classical education, a library now containing upwards of 12,000 volumes, and an observatory well furnished with astronomical instruments. Besides these, the city now contains a Roman Catholic chapel and a Presbyterian meeting-house, both on a large scale; and several places of worship for other religious denominations. Its other public buildings are, the cathedral, a cruciform building, more remarkable for its antiquity than its architectural beauty; the court-house, the prison, the charter-school, the barrack, the county infirmary, the lunatic asylum, and the fever hospital, which last was erected and is maintained at the expense of Lord John Beresford, the present primate.

Charitable institutions. The number of poor relieved at the charitable institutions just mentioned amounted in the year 1829 to 2678, and occasioned an expenditure of L.2562. Besides these there are eleven dispensaries in various parts of the county, the returns from six of which give an aggregate of 9558 individuals relieved during the same year, at an expenditure of L.967, one moiety of which is derived from the contributions of individuals, the other from grants of public money. In

Armagh city there is a mendicity society, which maintained 500 paupers during the same year, at an expenditure of L.584, being at the rate of L.1. 3s. 4¼d. each. The city is governed by a sovereign and twelve burgesses, who, when deaths occur, elect to the vacancies. The elective franchise is confined to the burgesses, and they uniformly return the archbishop's nominee as their representative. Although the linen trade has declined considerably, both here and throughout the north of Ireland, much of it is still manufactured in the vicinity of the city, and is disposed of at the market held here every Tuesday. (See Wakefield's *Ireland;* Barton's *Natural History of Lough Neagh;* Coote's *Statistical Survey of Armagh;* Shaw Mason's *Parochial Account of Ireland,* articles Creggan, Ballymoyer, and Seagoe; Erck's *Ecclesiastical Register;* Stewart's *History of the City of Armagh; Parliamentary Papers; Population Returns,* 1821; *Reports of Commissioners of Education,* 1814, 1824–26; *Report of Committee on the State of the Poor in Ireland,* 1830.)

ARMAMAXI, in *Antiquity,* a kind of Scythian chariots or carriages, composed of two wheels, variously adorned with crowns, shields, breastplates, and other spoils, carried in procession after the images of the gods and great men.

ARMATURA, in a general sense, is the same with what we otherwise call armour. It is more particularly used in the ancient military art to denote a kind of exercise performed with missile weapons, as darts, spears, arrows, and the like. In this sense armatura stands contradistinguished from palaria; the latter being the exercise of the heavy-armed, the former of the light-armed.

Ancient Armenia.

ARMENIA, a country of Asia, anciently divided into Armenia Major and Minor. Armenia Major was bounded on the south by Mesopotamia, on the east by Media, on the north by Iberia and Albania, and on the west by the Euphrates. The most considerable cities were Artaxata, Tigranocerta, and Theodosiopolis. Armenia Minor was bounded on the east by the Euphrates; on the south by Mount Taurus, which separated it from Cilicia; on the west and north by a long chain of mountains, called in different places *Mons Scordiscus, Amanus,* and *Antitaurus,* by which it was separated from Cappadocia.

Armenia is said to have been very early advanced to the rank of a kingdom. Berosus makes one Sytha the first founder of this monarchy, whose successor Bardanes, he says, was driven out by Ninus, king of Assyria. The Armenians were in course of time subdued by the Medes, to whom Astyages made them tributaries, but allowed them to be governed by their own kings; but on the dissolution of the Median empire by Cyrus, the kingdom was reduced to the form of a province, and they were governed by Persian prefects or lieutenants. On the destruction of the Persian empire by Alexander the Great, Armenia fell into the hands of the Macedonians, to whom it continued subject till the beginning of the reign of Antiochus the Great. This prince having appointed two prefects, named Zadriades and Artaxias, to govern Armenia, they excited the people to a revolt, and caused themselves to be proclaimed kings of the provinces over which they presided. Antiochus being then very young, they succeeded beyond their expectation, which encouraged them to attempt the enlargement of their territories. Accordingly, invading the neighbouring countries, they took from the Medes the provinces of Caspiana, Phaunitis, and Basoropida; from the Iberians, Chorzena and Gogorena on the other side of the Cyrus; from the Chalybes and Mossynæci, the provinces of Pareneta and Herexena, which bordered on Armenia Minor. On this occasion the division of the kingdom into Armenia Major and Minor first took place. Artaxias became king of Armenia Major, and Zadriades of Armenia Minor; and this distinction subsisted to later times.

By whom Artaxias was succeeded is not known; neither have we any account of the transactions of his reign, farther than that Antiochus led a powerful army against him and Zadriades, but without being able to recover a single province. Upon this he concluded a peace, designing to fall upon them at a proper opportunity; but they having entered into alliance with the Romans, by that means secured themselves in the possession of their kingdom. After this Artaxias was defeated and taken prisoner by Antiochus Epiphanes, but seems to have been restored to his kingdom.

From this time we meet with a chasm in the Armenian history for 70 years, during which all we know is, that Tigranes, the king's son, was delivered up as an hostage to the Parthians. On the news of his father's death, the Parthians set the young king at liberty, having first obliged him to give up a considerable part of his kingdom by way of ransom. Tigranes, thus restored to his father's kingdom, was prevailed upon in the beginning of his reign to enter into an alliance with Mithridates Eupator against the Romans, whose power began to give jealousy to all the princes of Asia. By their joint arms Cappadocia was conquered, and the son of Mithridates placed on the throne. Shortly after, the Syrians being harassed with a long and intestine war of the Seleucidæ, invited Tigranes to come and take possession of their country; which he accordingly did, and kept it for 18 years, till he was driven out by Pompey, and Syria reduced to the form of a Roman province. Encouraged by this success, he next invaded Armenia Minor, defeated and killed King Artanes, who opposed him with a considerable army; and in one campaign made himself master of the whole kingdom. From Armenia Minor he marched against the Asiatic Greeks, the Adiabenians, the Assyrians, and the Gordians, carrying all before him, and obliging the people wherever he came to acknowledge him sovereign. From this second expedition he returned home loaded with booty, which he soon after increased by the spoils of Cappadocia, invading that kingdom a second time at the instance of Mithridates, who had been obliged by the Romans to withdraw his forces from thence. From Cappadocia, Tigranes, besides other booty, brought back into Armenia no fewer than 300,000 captives, having surrounded the country with his numerous forces in such a manner that none could escape. These, together with the prisoners he had taken in his two first expeditions, he employed in building the city of Tigranocerta, which they afterwards peopled.

In the mean time Mithridates, who had concluded a peace with the Romans for no other end than to gain time, sent a solemn embassy to Tigranes, inviting him to enter into a second alliance against the common enemy. This he at first declined; but in the end was prevailed upon by his wife Cleopatra to send him considerable supplies, though he never came heartily into the war, not caring to provoke the Romans, who on their part kept fair with him, taking no notice for the present of the supplies he had sent Mithridates. That unfortunate prince being soon after defeated by Lucullus, was forced to fly for shelter into Armenia, where he met with a very cold reception from his son-in-law, who would neither see him, treat with him, nor own him as his relation; however, he promised to protect his person, and allowed him in one of his castles a princely retinue, and a table suitable to his former condition.

Though this total overthrow of Mithridates might have opened the eyes of Tigranes, and made him oppose with all his might the growing power of the Romans, he fool-

ishly left them to finish their conquest of Pontus, while he marched at the head of a very numerous army against the Parthians, with a design to recover from them the dominions they had formerly extorted from him before they set him at liberty. These he easily retook; and, not satisfied with what formerly belonged to him, he added to them all Mesopotamia, the countries that lay about Ninus and Arbela, and the fruitful province of Mygdonia; the Parthians, though at that time a mighty people, flying everywhere before him. From Mesopotamia Tigranes marched into Syria to quell a rebellion which had been raised by Cleopatra, surnamed *Selene;* who, after the death of her husband Antiochus Pius, reigned jointly with her sons in that part of Syria which Tigranes had not seized on. The malcontents were quickly reduced; and the queen herself was taken prisoner, and confined to the castle of Seleucia, where she was soon after put to death by the king's orders. From Syria Tigranes passed into Phœnicia, which he subdued either entirely or in great part, spreading far and wide the terror of his arms, insomuch that all the princes of Asia, except those who were in alliance with the Romans, either in person or by their deputies submitted and paid homage to the conqueror.

The king having now subdued all Syria to the borders of Egypt, and being elated with a long course of victories and prosperous events, began to look upon himself as far above the level of other crowned heads. He assumed the title of *king of kings*, and had many kings waiting upon him as menial servants. He never appeared on horseback without the attendance of four kings dressed in livery, who ran by his horse; and when he gave answers to the nations that applied to him, the ambassadors stood on either side of the throne with their hands clasped together, that attitude being of all others then accounted among the orientals the greatest acknowledgment of vassalage and servitude. In the midst of all this haughtiness, however, he was unexpectedly visited by an ambassador from Lucullus the Roman general, who, without any ceremony, told him, that he came to demand Mithridates king of Pontus, who had taken refuge in his dominions, and, in case of his refusal, to declare war against him. Notwithstanding his high opinion of himself, Tigranes returned a mild answer to this message, in which, however, he refused to deliver up his father-in-law; and being highly provoked at Lucullus for not giving him the title of *king of kings* in his letter, he did not even bestow upon him the title of *general* in his answer. He now received with the greatest pomp imaginable his father-in-law Mithridates, whom till that time he had not admitted into his presence, though he had resided a year and eight months in his dominions. They had several private conferences; and at last Mithridates was sent back to Pontus with 10,000 horse, to raise there what disturbances he could.

Lucullus, on the other hand, hearing the king's resolution to protect Mithridates, immediately began his march for Armenia, at the head of only two legions of foot and 3000 horse, having left 6000 men in Pontus to keep that country quiet. Having passed the Euphrates without opposition, he detached two parties; one to besiege a city where he heard that Tigranes's treasure and concubines were kept; and the other, under Sextilius, to block up Tigranocerta, in order to draw the king to a battle. But Tigranes, after having put to death the scout that brought him the first intelligence of the approach of the Romans, made towards Mount Taurus, which he had appointed for the place of the general rendezvous. The Roman general then despatched Muræna in pursuit of the king; and having overtaken him in a narrow pass, defeated him, and, besides all the baggage, carried off a great many prisoners, the king himself having fled in the beginning of the skirmish. After this he sent out several parties to scour the country, in order to prevent the innumerable forces of Tigranes from joining into one body. This, however, he was not able to effect: Tigranes was joined by such numbers of Gordians, Medes, Adiabenians, Albanians, Iberians, &c. that before he left Mount Taurus, his army consisted, according to Plutarch, of 150,000 foot armed *cap-à-pié*, 35,000 pioneers, 20,000 archers and slingers, and 55,000 horse.

Lucullus was so far from being dismayed at this formidable army, that the only fear he had was lest the king should follow the advice of Mithridates, which was, not to engage the Romans, but, by ravaging the country, distress them for want of provisions. In order to draw him to a battle, therefore, he formed the siege of Tigranocerta, imagining that Tigranes would never suffer that fine city to be taken without making an attempt to relieve it. The event fully answered his expectations: Tigranes having called a council of war, it was unanimously resolved to attack the Romans; and Taxilis, whom Mithridates sent to dissuade the king from venturing a battle, was in danger of losing his head on account of the advice he gave. The Roman general finding Tigranes disposed to come to an engagement, left Muræna with 6000 men to carry on the siege, while he himself marched against the king's vast army with only 10,000 men according to some, and the highest computations make them no more than 18,000. The Romans were at first greatly disheartened; but being encouraged by Lucullus, they immediately broke the Armenian army, who betook themselves to flight almost at the first onset. The Romans pursued them till night, making a most terrible slaughter. Plutarch informs us, that of the Armenians 100,000 foot were killed, and that very few of the cavalry escaped; whereas of the Romans only five men were killed and 100 wounded. Antiochus the philosopher, mentioning this battle, says that the sun never beheld the like; and Livy, that the Romans never fought to such a disadvantage, the conquerors not amounting to a twentieth part of the conquered. Tigranes in his flight having met with his son in as forlorn a condition as himself, resigned to him his royal robes and diadem, desiring him to shift for himself and save those royal ensigns. The young prince delivered them to a trusty friend, who, being taken by the Romans, consigned them to Lucullus.

While the king was making his escape after this terrible overthrow, he was met by Mithridates, who was marching to his assistance at the head of a considerable army. The king of Pontus cheered up his son-in-law as well as he could, and encouraged him to continue the war; advising him, instead of fruitlessly bewailing the present disaster, to rally his troops, raise new supplies, and renew the war, not questioning but that in another campaign he might repair all the losses he had sustained: but while the two kings were consulting upon these matters, Lucullus made himself master of Tigranocerta. From this city he marched into the small kingdom of Gordyene, where he celebrated with the utmost pomp the obsequies of king Zarbienus, whom Tigranes had put to death, lighting the funeral pile with his own hand. In this kingdom, besides immense sums of gold and silver, he met with such store of provisions as enabled him to carry on the war without putting the republic to any charge.

The two kings, having levied new forces, appointed their troops to rendezvous in the spacious plains on the other side of Mount Taurus; whereupon Lucullus leaving Gordyene, and passing by Mount Taurus, encamped close by the enemy. Several skirmishes happened for some time between the two armies without any considerable advantage; but Lucullus could by no means draw them

to a general engagement. Upon this he decamped, as if he designed to march to Artaxata and lay siege to that place, where Tigranes had left his wife and children, with great part of his treasures. He had scarce formed his camp when the enemy appeared, and sat down close by him. Lucullus did not allow them to fortify their camp, but immediately attacked them, and having put them to flight after a faint resistance, pursued them all night with great slaughter, took most of the chief officers prisoners, and returned the next day loaded with booty.

The Roman soldiers now, finding the cold very severe, though it was no later in the year than the autumnal equinox, requested their general to allow them to retire into winter quarters. This request he rejected with indignation, upon which they mutinied. Lucullus did all he could to persuade them to continue in their duty; and prevailed so far that they consented to lay siege to Nisibis, in hopes of booty. This place they took; and Lucullus, to the great satisfaction of his troops, took up his winter quarters there. The next year, however, his forces again mutinied, accusing him of amassing immense wealth for himself; and, throwing their empty purses at his feet, told him, that as he enriched himself alone, he might carry on the war by himself. He endeavoured to appease them as much as possible; but the sedition being fomented by a party who favoured Pompey the Great, at that time aspiring to the command of Lucullus's army, the latter found himself obliged to sit still and see Mithridates and Tigranes overrun Cappadocia, and recover all Armenia and great part of Pontus. They would have gained much greater advantages, had not a son of Tigranes taken arms against his father, and obliged him to divide his troops. The father and son coming to a pitched battle, the latter was defeated, and forced to save himself in Parthia, where he persuaded Phraates, king of that country, to assist him with a numerous army against his father. Phraates having laid siege to Artaxata, Tigranes the elder was obliged to hide himself in the mountainous parts of his kingdom; upon which the king of Parthia returned home. Of this Tigranes the father being apprised, immediately abandoned the fastnesses of the mountains; and falling upon his son at Artaxata, dispersed the rebels with great slaughter, and entered his metropolis in triumph. Tigranes the son first fled to Mithridates; but finding him reduced to great straits, having been overcome a few days before, with the loss of 40,000 men, by Pompey, he went over to the Romans, and led them into Armenia against his father as an ally of Mithridates.

Tigranes being now thoroughly humbled, willingly yielded to the Romans, Cappadocia, Syria, Cilicia, and that part of Phœnicia which he possessed, contenting himself with his paternal kingdom; and not only paid the fine of 6000 talents laid upon him, but made large presents to Pompey, and all the officers of his army, which procured him the title of *the friend and ally of the Roman people.* He afterwards entered into a war with Phraates, king of Parthia, by whom he was overcome, and would have been driven out of his kingdom, had not a peace been brought about by the mediation of Pompey. He ever after cultivated a strict friendship with the Romans. He died in the 85th year of his age, and was succeeded by his son Artuasdes, called by Josephus *Artabazes*, by Orosius *Artabanes*, and by others *Artoadistes.*

From this period to the time of Trajan, Armenia was governed by its own kings; but as they were plainly vassals to the Romans, though they did not take that title till the reign of the emperor Nero, their history falls to be considered under that of the Romans.

By Trajan the kingdom of Armenia Major was reduced to the form of a Roman province; but it soon recovered its liberty, and was again governed by its own kings in the reigns of Constantine the Great and his successor, to whom the kings of Armenia were feudatories. In the reign of Justin II. the Saracens subdued and held it till the irruption of the Turks, who possessed themselves of this kingdom, and gave it the name of *Turcomania.* The Turks, after the reduction of Armenia, invaded Persia, and other countries subject to the emperors of the East; which gave the Armenians an opportunity of shaking off the Turkish yoke, and setting up kings of their own, by whom they were governed till the country was again subdued by Occadan, or, as some style him, *Heccata*, the son of Genghis, and first khan of the Tartars. The Armenians were still permitted, however, to have kings of their own; for in our chronicles we find mention made of Leo, king of Armenia, who in the reign of Richard II. came into England to sue for aid against the Turks, by whom he had been driven from his kingdom. In the year 1472 of the Christian era, Ussan Cassanes, king of Armenia, succeeding to the crown of Persia, made Armenia a province of that empire; in which state it continued till the year 1522, when it was subdued by Selim II., and made a province of the Turkish empire.

Respecting Armenia Minor, we find very little recorded, except what has been already mentioned, and what falls under the Roman history. It was made a Roman province by Vespasian, continued so till the division of the empire, when it was subjected to the emperors of the East; and, on the decline of their power, was subdued, first by the Persians, and afterwards by the Turks, who gave it the name of *Genech*, and have kept it ever since.

Modern Armenia.

Modern Armenia comprises the greater part of the Armenia Major of the ancients, and is bounded on the north by Georgia and Mingrelia, on the west by the Euphrates, and on the south and east by the territories of Julamerick and the Persian province of Azerbijan. It is divided among the Turks, Persians, and Kurds, though their territorial rights are not very distinctly defined; nor would it be possible to bind down the wandering tribes of Kurds to any fixed limits. The Turkish pachalics are, Erzeroum, Akiska, Khars, Bayazid, Moosh, and Diarbekir. Those pachalics are divided into districts. The country is mountainous; but the mountains are finely wooded, and are interspersed with extensive plains and beautiful valleys, which yield every kind of grain, and abundance of the most delicious fruits, such as grapes, olives, oranges, peaches, apricots, nectarines, mulberries, walnuts, melons, apples, and pears. Those fertile regions are watered by the Araxes, as well as by the Euphrates and Tigris, and by their numerous tributary streams, and present all the varieties of beautiful scenery which arise from the combination of wood, water, and mountains. Wax and honey are obtained in the mountains, as well as raw silk, hemp, cotton, and tobacco, which are exported to Constantinople and Russia. Manna is also produced in sufficient quantities to be exported. The mineral productions are, silver, copper, loadstone, saltpetre, sulphur, and bitumen. Wheat and barley are the two crops most extensively cultivated; and of these three successive crops may be obtained in two years. The principal manufactures and trade of this country consist in copper and iron, silk and cotton, wine, tobacco, and manna. The native Armenians are industrious and commercial in their habits, and evince a strong propensity to visit foreign countries. They form the commercial class in the Persian empire, as well as in Asiatic Turkey; and they are scattered in various other parts of the world, where they are engaged in extensive mercantile enterprises, and bear uniformly a high character for integrity in their dealings. The country contains several barbarous tribes, who are ruled by their own

Armentières Armiers

independent chiefs, and who are addicted to plunder rather than to trade. Armenia contains several large towns, such as Erzeroum, with a population of 100,000; Diarbekir, Erivan, Van, population 50,000; besides others of inferior note, as Bayazid, Argish, and Betlis. Besides its numerous rivers, Armenia contains the great lake Van, the Arsisa of the ancients, which is 168 miles in circumference.

ARMENTIERES, a small handsome town in the department of the North, in France, containing 7600 inhabitants. It was taken by Louis XIV. in 1667, who dismantled it. The river Lys traverses the town, and forms a small harbour. Long. 3. 3. E. Lat. 50. 40. N.

ARMIERS, a town in France, in the department of the North, seated on the river Sambre. Long. 3. 45. E. Lat. 50. 15. N.

ARMIGER, a title of dignity belonging to such gentlemen as bear arms; and these are either by courtesy, as sons of noblemen, eldest sons of knights, &c.; or by creation, such as the king's servants, &c. See ESQUIRE.

ARMILLARY, in a general sense, something consisting of rings or circles.

ARMILLARY Sphere, an artificial sphere composed of a number of circles of the mundane sphere, put together in their natural order, to ease and assist the imagination in conceiving the constitution of the heavens and the motions of the celestial bodies. The armillary sphere revolves upon its axis within a silvered horizon, which is divided into degrees, and movable every way upon a brass supporter. The other parts are the equinoctial, zodiac, meridian, the two tropics, and the two polar circles.

ARMILUSTRIUM, in *Roman Antiquity*, a feast held among the Romans, in which they sacrificed, armed, to the sound of trumpets.

ARMINIANS, a religious sect, which arose in Holland, by a separation from the Calvinists. They followed Arminius, who, thinking the doctrine of Calvin with regard to free-will, predestination, and grace, too severe, began, in the year 1591, to express his doubts concerning them; and upon further inquiry adopted sentiments more nearly resembling those of the Lutherans. After his appointment to the theological chair at Leyden, he thought it his duty to avow and vindicate the principles which he had embraced; and the freedom with which he published and defended them exposed him to the resentment of those that adhered to the theological system of Geneva, which then prevailed in Holland; but his principal opponent was Gomar, his colleague. The controversy which was thus begun, became more general after the death of Arminius, in the year 1609, and threatened to involve the United Provinces in civil discord. The Calvinists, or Gomarists as they were now called, appealed to a national synod. Accordingly the synod of Dort was convened by order of the States General, in 1618, and was composed of ecclesiastical deputies from the United Provinces, as well as from the reformed churches of England, Hessia, Bremen, Switzerland, and the Palatinate. The principal advocate in favour of the Arminians was Episcopius, who at that time was professor of divinity at Leyden. It was first proposed to discuss the principal subjects in dispute, and that the Arminians should be allowed to state and vindicate the grounds on which their opinions were founded: but some difference arising as to the proper mode of conducting the debate, the Arminians were excluded from the assembly, their case was tried in their absence, and they were pronounced guilty of pestilential errors, and condemned as corrupters of the true religion. In consequence of this decision they were treated with great severity, they were deprived of all their posts and employments, their ministers were silenced, and their congregations were suppressed. However, after the death of Prince Maurice, who had been a partisan of the Gomarists, in the year 1625, the Arminian exiles were restored to their former tranquillity; and, under the toleration of the state, they erected churches and founded a college at Amsterdam, appointing Episcopius to be the first theological professor. The Arminian system has very much prevailed in England since the time of Archbishop Laud, and its votaries in other countries are numerous.

Arminius || Armoric.

The Arminians are also called *Remonstrants*, from a humble petition, entitled their *Remonstrance*, which, in the year 1610, they addressed to the states of Holland. Their principal writers are Arminius, Episcopius, Vorstius, Grotius, Curcellæus, Limborch, Le Clerc, and Wetstein; not to mention many others of more modern date.

ARMINIUS, JAMES, whose real name in Low Dutch was James Harmanni, a famous Protestant divine, was born at Oude water, in Holland, in 1560. He was ordained minister at Amsterdam on the 11th of August 1588, where he soon distinguished himself by his sermons, which were remarkable for their solidity and learning. Martin Lydias, professor of divinity at Franeker, judging him a fit person to refute a writing in which Beza's doctrine of predestination had been attacked by some ministers of Delft, Arminius at his desire undertook the task; but upon thoroughly examining the reasons on both sides, he came into the opinions he proposed to overturn, and afterwards went still farther than the ministers of Delft had done. In 1600 he opposed those who maintained that ministers should subscribe the confession and catechism every year. In 1602 a pestilential disease raged at Amsterdam, during which he acted with the greatest resolution and courage, in assisting the poor and comforting the sick; and Lucas Trelcatius and Francis Junius dying of that disease at Leyden, the curators of that university chose Arminius professor of divinity there, and he was afterwards made doctor of divinity. Disputes upon grace were soon after kindled in that university; and he was at length engaged in a new contest, occasioned by a disputation of his concerning the divinity of the Son. These contests, his continual labour, and the concern of seeing his reputation blasted by a multitude of slanders in relation to his opinions, impaired his health, and threw him into a fit of sickness, of which he died on the 19th of October 1609. Arminius was esteemed an excellent preacher; his voice was low, but very agreeable; his pronounciation admirable; he was easy and affable to persons of all ranks, and facetious in conversation amongst his friends. The curators of the university of Leyden had so great a regard for him, that they settled a pension upon his wife and children. He left several treatises, viz. 1, Disputationes de Diversis Christianæ Religionis Capitibus; 2, Orationes, itemque Tractatus Insigniores aliquot; 3, Examen modesti Libelli Gulielmi Perkinsi de Prædestinationis Modo et Ordine, itemque de Amplitudine Gratiæ Divinæ; 4, Analysis Capitis Noni ad Romanos; 5, Dissertatio de vero et genuino Sensu Capitis Septimi Epistolæ ad Romanos; 6, Amica Collatio cum D. Francisco Junio de Prædestinatione, per literas habita; 7, Epistola ad Hippolytum a Collibus. These pieces were collected in a 4to volume, published at Leyden in 1629, which has been several times reprinted.

ARMISTICE, in military affairs, a temporary truce or cessation of arms for a very short space of time. The word is Latin, *armistitium*, and compounded of *arma*, arms, and *sto*, to stand or stop.

ARMOISIN, a silk stuff, or kind of taffety, manufactured in the East Indies, at Lyons in France, and at Lucca in Italy. That of the Indies is slighter than those made in Europe.

ARMORIC, or AREMORIC, something that belongs to the province of Bretagne or Britany, in France. The

name *Armorica* was anciently given to all the northern and western coast of Gaul, from the Pyrenees to the Rhine, under which name it was known even in Cæsar's time. The word is of Bas-Breton origin, and signifies *maritime;* compounded, according to M. Menage, of *ar*, upon, and *more*, sea.

ARMORY, a storehouse of arms, or a place wherein military habiliments are kept, to be ready for use. There are armories in the Tower, and in all arsenals, citadels, castles, &c.

ARMOUR, a defensive habit, wherewith to cover and secure the body from the attacks of an enemy. In ancient statutes this is frequently called *harness*. A complete armour anciently consisted of a casque or helm, a gorget, cuirass, gauntlets, tasses, brassets, cuishes, and covers for the legs, to which the spurs were fastened. This formed armour *cap-à-pié*, and was used by the cavaliers and men-at-arms. The infantry had only part of it, viz. a pot or headpiece, a cuirass, and tasses; but all light. Lastly, the horses themselves had their armour, wherewith to cover the head and neck. Of all this furniture of war, scarce any thing is now retained except the cuirass; the gorget or neck-piece worn by officers being at present only a badge of honour, and of no defence.

Armour, *Coat*, is the escutcheon of any person or family, with its several charges, and other furniture; as mantling, crest, supporters, motto, &c. Thus we say, a gentleman of coat armour, meaning one who bears arms.

ARMS, Arma, in a general sense, includes all kinds of weapons, whether for defence or offence. Arms of stone and of brass appear to have been used before those of iron and steel. Josephus assures us that the patriarch Joseph first taught the use of iron arms in Egypt, arming the troops of Pharaoh with a casque and buckler. What contributed most to render the Romans masters of the world was, that having successively warred against all nations, they constantly renounced their own methods, arms, &c. wherever they met with better. Thus Romulus, during his war with the Sabines, a bold and warlike nation, adopted their broad buckler, in lieu of the small Argian buckler, which he had used till that time.

Arms, or *Armories*, in *Heraldry*, marks of dignity and honour, regularly composed of certain figures and colours, given or authorized by sovereigns, and borne on banners, shields, coats, &c. for the distinction of persons, families, and states, and passing by descent to posterity. They are called *arms*, in regard they were borne principally on the buckler, cuirass, banners, and other apparatus of war. They are also called *coats of arms*, *coat armour*, &c. because anciently embroidered on surcoats, &c. See Heraldry.

ARMSTRONG, John, M.D. an eminent physician, poet, and miscellaneous writer, was born in Castletown parish, Roxburghshire, where his father and brother were ministers; completed his education in the university of Edinburgh, where he took his degree in physic, February 4, 1732, with much reputation; and published his thesis, as the forms of that university require; the subject of which was *De Tabe Purulenta*. In 1735 he published a little humorous fugitive pamphlet in 8vo, entitled *An Essay for abridging the Study of Physic; to which is added, a Dialogue betwixt Hygeia, Mercury, and Pluto, relating to the practice of Physic as it is managed by a certain illustrious Society; as also an Epistle from Usbeck the Persian to Joshua Ward, Esq.* This piece contains much fun and drollery; in the dialogue, he has caught the very spirit of Lucian. In 1737 he published *A Synopsis of the History and Cure of the Venereal Disease*, 8vo. This was soon followed by the *Economy of Love*, a poem which has much merit, but, it must be confessed, is too strongly tinctured with the licentiousness of Ovid. It is said, however, that his maturer judgment expunged many of the luxuriances of youthful fancy, in an edition "revised and corrected by the author" in 1768. It appears by one of the cases on literary property, that Mr Millar paid 50 guineas for the copy-right of this poem, which was intended as a burlesque on some didactic writers. It has been observed of Dr Armstrong, that his works have great inequalities, some of them being possessed of every requisite to be sought after in the most perfect composition, while others can hardly be considered as superior to the productions of mediocrity. *The Art of preserving Health*, which was published in 1744, is his best performance. In 1746 Dr Armstrong was appointed one of the physicians to the hospital for lame and sick soldiers behind Buckingham House. In 1751 he published his poem *On Benevolence*, in folio; and in 1753, *Taste, an Epistle to a young Critic*. In 1758 appeared *Sketches or Essays on various subjects, by Launcelot Temple Esq. in two parts*. In this production, which possesses much humour and knowledge of the world, and which had a remarkably rapid sale, he is supposed to have been assisted by Mr Wilkes. In 1760 he was appointed physician to the army in Germany, where, in 1761, he wrote a poem called *Day, an Epistle to John Wilkes of Aylesbury, Esq.* In this poem, which is not collected in his works, he wantonly hazarded a reflection on Churchill, which drew on him the vengeance of that severest of satirists. In 1770 Dr Armstrong published a collection of Miscellanies, in 2 vols., containing, 1, The Art of preserving Health; 2, Of Benevolence, an Epistle to Eumenes; 3, Taste, an Epistle to a young Critic, 1753; 4, Imitations of Shakspeare and Spenser; 5, The Universal Almanack, by Noureddin Ali; 6, The Forced Marriage, a tragedy; 7, Sketches. In 1771 he published *A short Ramble through some parts of France and Italy, by Launcelot Temple;* and in 1773, in his own name, a quarto pamphlet, under the title of *Medical Essays;* towards the conclusion of which he accounts for his not having such extensive practice as some of his brethren, from his not being qualified to employ the usual means. He complains much of the behaviour of some of his brethren, of the herd of critics, and particularly of the reviewers. He died in September 1779.

ARMUYDEN, a seaport town of the United Provinces, in the island of Walcheren, formerly very flourishing, but now inconsiderable. Long. 3. 40. E. Lat. 51. 30. N.

ARMY.

Army. Definition.

An army, says Dr Johnson,[1] is "a collection of armed men obliged to obey one man." This definition, however, has little else than its brevity to recommend it. An army, it is true, is "a collection of armed men," and such a "collection" is generally "obliged to obey one man," that is to say, it is commonly placed under the exclusive control and direction of an individual chief or leader. But it does not follow that "a collection of armed men obliged to obey one man" is the distinguishing or principal characteristic of an army, since a gang of robbers or banditti would equally answer this description. To be at all applicable, therefore, the definition of army must be at once more comprehensive and more precise; in other words, it must include the specification of those peculiar circumstances or attributes, the aggregate of which constitutes the complex idea sought to be resolved. Hence an army may, we think, be more accurately defined, a certain portion of the community selected, raised, or assembled, for the defence of the state, by means of conscription, voluntary enrolment, tenure of military service, or otherwise; armed, disciplined, and organized, conformably to a given system, which is considered best calculated for giving full development and efficacy to its collective force; and commanded by a chief or leader, with subordinate officers in regular gradation, to carry his orders into effect, and move the living machine, thus constructed, as he shall think proper to direct. It is an artificial or scientific combination of a great number of powers, individually small or insignificant, so as, by their union and concentration, to accomplish mighty and important deeds; a force which states and nations create out of the elements of their strength, as mechanicians form engines by taking advantage of and skilfully combining the action of the primary mechanical powers; an instrument, in short, so contrived as, though originally intended for the best, to be equally available for the worst purposes, being alike fitted for defence or aggression, for protection or conquest, for restraining and punishing the dishonest ambition of others, or affording the means of gratifying our own. An army, therefore, may be considered a species of movable engine, composed of a vast number of individual parts or powers, so arranged and organized as not only to act in concert, but to exert their whole aggregate force in any direction and upon any point which may be ordered or required. At the present day this denomination is applied to any given number of soldiers, consisting of artillery, infantry, and cavalry, of various descriptions, all completely armed and provided with engineers, a train of artillery, ammunition, magazines, commissariat, and other necessary adjuncts, subject to the command of a general, having under him lieutenant-generals, major-generals, brigadier-generals, colonels, majors, captains, and subalterns:[2] And an army is now composed of battalions or squadrons, regiments, brigades, divisions, and sometimes corps d'armée; two or more battalions or squadrons forming a regiment, two or more regiments a brigade, two or more brigades a division, and two or more divisions a corps d'armée. So much for definition and description.

General observation.

Were we called upon to trace to its origin the history of war, we should find it necessary to ascend through every form and gradation of society to the very cradle of the human race. Admitted on all hands to be one of the greatest evils, war is also, unhappily, one of the oldest. "Il est triste d'imaginer," says a celebrated military writer, "que le premier art qu'aient inventé les hommes, ait été celui de se nuire, et que, depuis le commencement des siècles, on ait combiné plus de moyens pour détruire l'humanité que pour la rendre heureuse."[3] This is a truth which cannot be disputed. The passions of rivalry, jealousy, hatred, revenge, cupidity, thirst of power or ambition, were born with the world; and these, in their turn, gave birth to war, which again produced the desire of conquering or combating with success. But, in proportion as this desire came to prevail, men would naturally be led to reflect as to the means best fitted to insure its gratification: and as experience must soon have convinced them that the battle was not always to the strong, nor the race to the swift,—or, in other words, that mere brute force, openly applied, was in many cases insufficient to secure the victory, and, in most, productive of a loss that countervailed it,—they must early have discovered that some degree of combination was requisite, and certain extrinsic qualities necessary, to render it effectual; that violence might find an auxiliary in cunning, and resistance be paralysed by stratagem and surprise. Such, accordingly, is the state of things which generally obtains amongst savage tribes, however warlike and enterprising. They seldom go down to battle openly and boldly; nor do they consider victory, when dearly purchased, as either honourable or desirable. Artifice is their main resource. The first principle of their simple tactics is to steal unperceived upon the enemy, and overwhelm him, while unsuspicious of attack and unprepared for resistance. In this and similar principles, however, we discover the origin and primary development of the military art. Its source is in the forest or the wilderness. But as war is the first art which men invented, so it is also that which was soonest cultivated and improved. It kept pace with the progress of society;—as mankind multiplied, and communities extended themselves, it received a corresponding expansion;—more means were combined, and a greater number of men were assembled. This was the second stage of the art, where it remained long stationary, and in nearly the same state in which we find it at the present day among some of the Asiatic nations. Science had not digested nor systematized the rude and shapeless mass of knowledge which experience had supplied, or suggested new combinations of existing means. But ambition at length gave a fresh stimulus to improvement, by opening up a new theatre for its expansive energies; and successive conquerors contributed largely to the cultivation of an art which became the instrument of their glory. In their hands, accordingly, it determined the destiny of nations;—it raised up or destroyed empires;—it produced mighty revolutions;—it overthrew old dynasties, and created new ones in their stead;—and, amidst all the havoc and desolation occasioned by the pursuit of false glory, it contributed, upon the whole, to the cultivation of those sciences and arts which have a tendency to mitigate the natural ferocity of man, and ultimately to render conquest itself less destructive, and war less sanguinary.

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[1] *Dictionary*, *voce* Army.

[2] James's *Military Dictionary*, *voce* Army.

[3] *Essai Général de Tactique*, par Guibert, vol. i. p. 59, *Disc. Prélim.* Paris, 1803.

Army.

Results so vast leave no doubt whatever, that the art which was principally instrumental in producing them, must have made considerable progress at a very remote period of the world. It is in fact in the early and semi-barbarous stage of society that the military virtues are found in the greatest perfection. The mind is then fierce, ardent, energetic, and daring; peculiarly accessible to the illusion of warlike renown, and undistracted by any of those influences or impressions which act so powerfully upon man in civilized life; while the body, unpampered by luxury, unenfeebled by indulgence, is a fit companion for such a spirit, and capable of enduring, without difficulty, the fatigues and privations incident to war. Add to this that, at the period of which we speak, the only law generally recognised and respected is the law of the strongest; that the necessity of self-defence, of protecting person and property from violence and spoliation, keeps men continually prepared to repel force by force, or to retaliate one aggression by another; that, consequently, the disorders which distract society re-act upon and foster the turbulent spirit in which they have their origin; that war thus becomes a trade which all are either disposed or compelled to pursue; that, to bold and adventurous spirits, it opens up the only path which leads to fortune and to fame, and thus holds out irresistible temptations to embark in military enterprises. At such a period all men are soldiers, and war is their natural employment; in it they live and move and have their being. But necessity is the parent of invention, and the mother of arts; and to it the science of war was indebted for its first improvements. Armies are unwieldy machines, which cannot be moved without some degree of organization, nor supported without considerable care and foresight, nor led into action with an enemy without a certain knowledge of tactical combinations. It is obvious, therefore, that wherever we read of such masses of men having been assembled, whether for purposes of aggression or defence, we may safely consider this fact as of itself conclusive, that the military art had there reached the second stage of its progress, or, in other words, had made considerable advances. History may be silent as to the precise extent to which improvement had been carried, and the records of the past may afford no clue to direct our inquiries concerning the composition and organization of the armies of remote antiquity; but if it be once admitted that such armies existed, and that they defended some countries and overran or conquered others, this admission will imply no inconsiderable knowledge of the art of war on the part of those by whom they were organized and directed. Discipline of some kind or other is the bond which keeps together large bodies of men: without it they are a mere mob or rabble, incapable alike of action or direction, and formidable to none save the people of the country where they happen to have congregated. Even the Tartar hordes of Genghis Khan and Timour had an organization and discipline of their own, by means of which these barbarian conquerors were enabled to impel their fierce and warlike masses against the enfeebled and effeminate soldiery of countries advanced in wealth and in civilization;[1] and the same observation applies still more forcibly to the Asiatic and Turkish armies of our own time. In a word, we may adopt with some qualification the remark of Guibert, when speaking of the progress of the military art: "Il précéda," says he, "chez tous les peuples, les arts et les sciences, et y périt à mesure que celles-ci s'étendirent."[2] The details into which we are about to enter will fully illustrate the truth of these general observations.

Ancient Egyptian army.

The earliest military establishment of which history has preserved any record is that of Egypt under the reign of Sesostris, or, as he is denominated in the monumental sculptures of that wonderful country, Rhamses;[3] who was considered the greatest of the Egyptian kings after Osiris,[4] and has generally been supposed by chronologists to have flourished about seventeen centuries before our era.[5] But Osiris was an ideal being, the offspring of mythology, and the hero of fable, adored by the Egyptians sometimes as a deified mortal, sometimes as a personification of the Nile, and sometimes as the symbolical representative of the solar orb. Sesostris, on the contrary, is claimed by history as a real personage; and although the accounts which have been preserved of the reign of this prince, chiefly by the Greek historians, are dashed with a considerable admixture of exaggeration and romance, we cannot reasonably doubt the existence of the monarch, however we may be inclined to question the exploits of the hero and the achievements of the conqueror. The substance of these accounts, indeed, when considered in connection with the corroborative evidence supplied by the Egyptian monuments, and the traces of his expedition which remained even in the age of Herodotus, may be regarded as the more deserving of credit that, while scepticism has little to oppose to them except its own incredulity, the statements of the Greek historians are not only consistent with one another, but in strict accordance with the uniform tradition and belief, as well as with the records, of that country, the mother of arts and civilization, which, under this renowned

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[1] Timour or Tamerlane, of whom unfortunately we know so little, has left an institutional or elementary treatise on war and the art of conducting armies, each page of which affords proof of a natural genius for commanding men, as well as of tact and skill in employing them to the best advantage. See *Instituts de Timour*, par Langlès; also Jomini, *Traité des Grandes Opérations Militaires*, tome viii. p. 678. Paris, 1616.

[2] *Essai Général de Tactique*, vol. i. p. 60.

[3] One of the difficulties which occur in our inquiries concerning Sesostris arises from the different names by which he has been designated by ancient writers. He has been variously called Sesostris, Sesoosis, Sesochis, Sesonchosis, Sethosis, Sethos, Ramesses, Rameses, Rhamses, Ramestes, Rampses, Vexores, and Ægyptus. But most of these appellations were probably titular. Thus, *Sesostris* may be Se-sios-t-re, which signifies, *filius domini, donum solis; Sesoosis* may, in like manner, be a corruption for Se-sios-sios, *filius domini dominorum;* and *Rhamses* or *Ramesses*, derived from Re, *sol*, and Mes, *gignere*, may signify *Begotten by the Sun.* But it is not always possible to render ancient Egyptian names according to the grammatical rules established in the Coptic language, and, therefore, such etymologies as those now proposed are to be received as purely conjectural. The common designation of this monarch on the monuments is Rameses-Meiamoun, *Rhamses beloved of Ammon;* or, adopting the etymology of *Rhamses* just proposed, *Begotten by the Sun, Beloved of Ammon;* in which case both appellations would be merely titular. *Vide* Sir W. Drummond's *Origines*, book iv. chap. 13, and Champollion's *Précis du Système Hiéroglyphique*, p. 223. Paris, 1824.

[4] Manetho *apud Euseb. Chron.* lib. i. In Manetho *apud Josephum contra Appionem*, lib. i. p. 1053, this monarch is indifferently called *Ramesses* and *Rampses.*

[5] Chronologists have been unable to fix the precise date of the reign of Sesostris. Larcher, the celebrated translator of Dionysius of Halicarnassus, adopts and defends with much warmth the chronography of Herodotus; while others, rejecting the authority of the father of history, endeavour to determine the era of the Egyptian monarch from the scanty data furnished by Diodorus and Strabo. The objections to the conclusions of Larcher, stated by Sir William Drummond in his *Origines*, book iv. chap. 13, appear to be perfectly unanswerable.

sovereign, is supposed to have reached an unprecedented height of military glory.

Sesostris, however, did not create the military spirit to which he appears afterwards to have given such ample development. This was in a great measure the work of his father, Amenophis III., who, shortly after the birth of his son, is said to have assembled all the male children born on the same day, and to have given them the same education. No distinction was made between the young prince and his companions. They were alike engaged in the same studies, trained to the same exercises, inured to the same hardships, and instructed in the use of the same arms. A rigid discipline prescribed unremitting exertion, while daily privations and fatigue hardened and prepared them for the duties of war. In establishing this military seminary, Amenophis appears to have intended placing around his son a faithful band of soldiers, attached to him by the associations of early friendship, and the ties of brotherhood in arms. Nor did the result disappoint his expectations. Arrived at manhood, the prince and his companions soon evinced how much they had profited by their education,—how well they merited the confidence reposed in them. With bodies rendered vigorous and athletic by labour and exercise, and with minds cultivated by the best studies, they were already fitted to act both as soldiers and as generals, to serve with energy, or to command with skill. Sent by his father at an early age to command an expedition against the Arabians, the prince, accustomed, as well as his companions, to suffer long both from hunger and from thirst, could meet upon equal terms the wandering and yet unconquered tribes, who chiefly trusted for their defence to the barrenness of their inhospitable deserts. Arabia was subdued and annexed to the Egyptian monarchy. He afterwards directed his march to the west, and his father lived to see the greater part of Libya conquered by his victorious son. When Sesostris mounted the throne, therefore, his military fame was established. The qualities of his mind, his dauntless courage, and his daring ambition, seemed to be announced by his personal appearance; and the people, no doubt, easily associated the character of the hero with the robust frame and gigantic stature[1] of their new monarch. But it is more material to state, that the success of his arms, in his wars with the Arabians and Libyans, had inspired him with the hopes of making yet more extensive conquests; and, if we may credit the Greek historians, the perilous project of subjugating the world must have been already familiar to the mind of Sesostris when he succeeded to the crown. Amidst the burning sands of Libya, and in the depth of the Arabian deserts, the phantom of universal empire showed itself, and he vowed to pursue it.[2]

His resolution being thus taken, no time appears to have been lost by the new sovereign in preparing his subjects for an enterprise, which could not be undertaken but in defiance of all the counsels of prudence. He caused various reports to be spread abroad, artfully attributing his project to other causes than his own ambition. His daughter Athyrtis, famed for her wisdom, as a sort of Egyptian Cassandra, proclaimed the facility with which her father would conquer the earth: the success of the enterprise was prognosticated by omens, by sortilege, and by divination: and the people were reminded that, at the birth of Sesostris, Phtha had appeared to his father in a dream, and had predicted to Amenophis that the new-born boy should one day become master of the world.[3] Nor did the Egyptian king content himself with influencing opinion in his favour by means of prophecies, prodigies, and visions. His natural sense taught him that other and more rational precautions were necessary; that a king who is not popular at home, should not think of making conquests abroad. His first object, therefore, was to secure the affections of the Egyptians: and for this purpose he employed all those arts which, exercised by sovereigns, are so powerful in conciliating popular favour. Some he won by his munificence, others by his clemeney; the selfish were secured by his liberality, the vain were flattered by his condescension and affability; even traitors to the royal authority were allowed to escape with impunity, and public debtors were liberated from the prisons in which they were confined.[4] On the other hand, that he might provide for the tranquillity of his kingdom, and leave none behind him who either would or could attempt a revolution in his absence, he made a partition of power among the chief men of the nation, dividing the whole territory of Egypt into thirty-six nomes or prefectures, over which he appointed as many governors, each of whom was charged with the collection of the royal revenues, and the administration of the laws within his own particular district. He at the same time elevated his brother Armais to the rank of regent of the kingdom; and, except that this prince might not wear the royal diadem, he was permitted to assume all the pomp of a monarch; an indulgence which he so far abused as to usurp the crown in the king's absence, and to attempt his life on his return home from his long and perilous expedition.[5]

Having completed these and other necessary arrangements, Sesostris next proceeded to raise an army. The peace establishment of the kingdom, as previously organized by this prince, appears to have consisted of a numerous militia, divided into two classes, denominated *kalasires* and *harmatopoii*, and amounting, according to Herodotus, to 410,000 men, distributed throughout the different provinces as a species of military colonists, each man being allowed a portion of land adequate to the maintenance of himself and family. This formed the nucleus of the mighty force which Sesostris now raised for the conquest of the world, consisting, if we may believe Diodorus Siculus, of 600,000 infantry, 24,000 cavalry, and 27,000 war chariots; a force certainly equal to the magnitude of the enterprise in which he was about to engage, though it is difficult to conceive how the population of a small country like Egypt, supposing it ever so dense, could have supplied so vast a body of men, exceeding, by more than 200,000, the numerical strength of the army with which the Emperor Napoleon invaded Russia, and which was by far the largest ever assembled in modern times. No precise information has reached us as to the composition, organization, and discipline of this expeditionary army. We only learn, incidentally as it were, that the king chose as the leaders of his less experienced troops, the companions of his youth, trained, like himself, to the use of arms, and exceeding 1700 in number; that disgrace or infamy was attached to disobedience of orders and neglect of duty, and that meritorious or valorous deeds were liberally rewarded; circumstances which, taken in connection with the particulars above stated, seem to warrant the conclusion, that the military system of Egypt had reached no small degree of improvement, and that the science of war, in all its branches, had made considerable advances. With

[1] Sesostris was four cubits and four palms, or about seven feet in height, and seemed formed by nature to sustain all the toils and fatigues to which his active life was afterwards exposed. Diodorus, lib. i. sect. 55.

[2] Drummond's *Origines*, book iv. c. 13.

[3] Diodor. Sic. lib. i. sect. 53.

[4] Diodor. Sic. lib. i. sect. 54.

[5] Drummond's *Origines*, *loc. supr. cit.*

Army. a view to the ulterior objects of the expedition, Sesostris also collected or fitted out a fleet of 400 sail; and the ships are said to have been of large dimensions, adapted to the purposes both of war and transport.[1]

With these immense preparations the warlike monarch at length commenced his perilous enterprise. He invaded Ethiopia, and compelled the inhabitants to pay him a tribute in ebony, gold, and ivory. Even the ferocious Troglodytes yielded to the conqueror. Advancing farther to the southward, he passed the frontiers of Ethiopia, and entered the country extending beyond Sennaar to the Mountains of the Moon, where he left various monuments both of his power and of his piety. In the Straits of Dira or Babelmandeb he joined his fleet, consisting, as above stated, of 400 sail, which had already compelled the inhabitants of the islands in the Erythrean Sea, and of the adjacent continent, to acknowledge his authority. The victorious monarch next proceeded to India, which he completely overran, extending his conquests beyond the Ganges, and subduing some of the countries which lie between that river and the Eastern Ocean. He then directed his course towards the country of the five rivers or Punjab; crossed the immense reticulation of streams, which ultimately unite their waters with the Indus; and ascended the table-land of central Asia. Nor were the Scythian nations able to resist the torrent as it rolled westward through Tartary, behind the mountains of Imaus, and north of the Caspian, to the river Tanais and the Palus Mœotis. Having entered Europe, Sesostris passed through Sarmatia, Dacia, and Mœsia, nor halted until he arrived in Thrace, where he erected columns to perpetuate the memory of his victories, and to prove the extent of his conquests. From Thrace he crossed over into Asia Minor, and advanced into the plains of Colchis (rendered so famous in Grecian story by the expedition of the Argonauts and the fable of the golden fleece), where he founded a colony on the banks of the Phasis, and erected monuments, some of which were in existence in the age of Herodotus. He then marched against the Assyrian empire, which he conquered, and thus seated himself on the throne which had been occupied by Ninus and Semiramis. Finally, surrounded with the trophies of victory, and enriched with the spoils of nations, Sesostris returned to Egypt in triumph, after having been thirty years engaged in an expedition, undertaken in defiance of all the dictates of prudence, yet, if we believe the concurrent testimony of historians, terminated without a single reverse of fortune.[2] Such is the military story of the renowned Rhamses.[3] That it involves many improbabilities is obvious; but what portion of ancient history is free of them? Mankind, in every age of the world, have taken delight in the marvellous; and if the ancients appear to have been pleased with reading romances in history, the moderns seem equally disposed to read history in romances. The great difficulty in forming an accurate judgment as to the story of the Egyptian monarch arises from the total want of details. We hear nothing of the generals to whom he was opposed, of the cities which he besieged, nor even of the battles which he fought. Historians relate his triumphs, but are silent respecting the skill which obtained them. At the same time, it cannot reasonably be doubted, we think, that there is a large substratum of truth in the narratives which have reached us respecting this extraordinary personage. By the concurrent testimony of the ancient authors, confirmed by the evidence derived from the Egyptian monuments, he is represented as a great warrior and conqueror; as the first, and, we may almost add, the last, of the Pharaohs who pursued the phantom of military renown, and sought for glory in distant expeditions: nor are there wanting circumstances which warrant the conclusion, that he overran some countries, conquered others, and left traces of his progress in many parts both of Asia and Europe. That he established a regular army, and provided a fleet to co-operate with it in his expedition against the countries of the East, are facts which seem to be as well attested as any in ancient history.[4]

Persian armies.

"C'est chez les peuples d'Asie, chez les Perses surtout," says Guibert, "que l'art de la guerre commença à prendre quelque consistance;" but he adds, "après la mort de Cyrus, le luxe lui fit quitter la Perse, et il passa chez les Grecs."[5] This remark, however, must be taken with some important qualifications. As a general proposition, it is doubtless true that the military art first assumed consistence among the Asiatic nations, particularly the Persians; for the warlike spirit of Egypt seems to have expired with its first and only conqueror. But it is utterly absurd to maintain that the death of Cyrus was productive of any change in the military system of Persia, or that this event led to the transference which Guibert has so gratuitously supposed. Cyrus, in as far as we are able to distinguish his character, and form a judgment

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[1] *Origines, ubi supra.*

[2] Diodorus, lib. i. sect. 54 and 55; Strabo, lib. xvi.; Herodotus, lib. ii. c. 103 and 110; Manetho *apud Joseph. contr. Apion.*; Julius Africanus *apud Syncellum.* In all the countries through which he passed, Sesostris left monuments behind him; and where he encountered serious resistance, the columns he erected bore this inscription: "Sesoosis, King of Kings, and Lord of Lords, has subdued this region by force of arms." Diodorus, *ibid.*

[3] The information given to Germanicus when he visited the ruins of Thebes, by some of the elder Egyptian priests, relative to this monarch, and the military establishment he had created, is thus recorded by Tacitus in the second book of his Annals: "Mox (Germanicus) visit veterum Thebarum magna vestigia; et manebant structis molibus litteræ Ægyptiæ, priorem opulentiam complexæ; jussusque e senioribus sacerdotum patrium sermonem interpretari referebat habitâsse quondam *septingenta millia* ætati militari: atque eo cum exercitu regem Rhamsen Libya, Æthiopia, Medisque et Persis, Bactriano ac Scytha potitum; quasque terras Suri Armeniique et contigui Cappadoces colunt, inde Bithynum, hinc Lycium ad mare imperio tenuisse," &c. The strength of the army of Sesostris, as here stated, very nearly coincides with the amount given in the text, on the authority of Diodorus. According to the latter, this army consisted of 600,000 infantry, 24,000 horse, and 27,000 armed chariots; which, as at least *three* men fought in *one* chariot, would make a total of 695,000 men, or only 5000 less than the number reported by the priests to Germanicus on the faith of the monuments.

[4] *Origines, ubi supra.* "It would be in vain," says Sir William Drummond, "to deny to the traditions of ages, to the records of history, and to the authority of monuments, that Sesostris must have been one of the greatest princes that ever lived; while we may fairly confess our doubts of the extent of his conquests, and acknowledge that we cannot ascertain at what period he flourished. The existence of the monarch we may consider as certain; and some of the achievements of the conqueror we may admit to be probable, though we cannot fail to perceive, that the number of his triumphs has been amplified by exaggeration, and the history of his reign crowded with fictions. It is known that the great Ramesses or Ramestes created at least one obelisk, on which he announced himself to be loved and gifted by all the gods of Egypt; but it may be questioned whether he had a right to call himself the master of the whole habitable world. We may believe that Sesostris obtained many victories, and subdued many regions; while we may still avow that we are unable to tell when this mighty monarch reigned, where were the limits of his empire, what humbled nations bowed down before his throne, or what captive kings were yoked to his triumphal car."

[5] *Essai Général de Tactique*, vol. i. p. 61.

of his achievements, appears to have been a wise prince, a warlike monarch, and a great conqueror;[1] while the victories achieved by the Persians under his command, contrasted with the fatal reverses which they afterwards experienced, may induce superficial observers to imagine that the knowledge of the art declined after the hero's death. No opinion, however, can possibly be more erroneous; except, indeed, it be that which represents the Greek tactics as having been primarily derived from the Persian, to which, as will appear in the sequel, they bore not the slightest resemblance. The qualities of the Persian troops may, perhaps, have deteriorated, and, under the influence of luxury and refinement, the military character of the nation may have declined; but the system of organising armies and making war continued, in a great measure, unchanged: nor, as far as the military art is concerned, would it be easy to discover any material difference between the tactics of Cyrus, who was uniformly victorious, and those of Xerxes, Mardonius, and Darius, who experienced the most disastrous defeats. It should also be remembered, that the former led Asiatics against Asiatics, and that the nations he subdued were among the most effeminate and voluptuous of the ancient world: whilst the latter were called to contend with the Greeks in their best days, when their bodies were robust, their hearts strong, and their discipline admirable; and when their armies were commanded by men fired alike with the love of liberty and of glory, and not only conversant with the science of war, theoretically considered, but eminently skilful in all those resources which neutralize superiority of numbers, and enable handfuls of men to snatch the victory from masses apparently overwhelming and invincible.

The strength of the Persian army consisted in its cavalry, which was always of excellent quality, and capable of achieving great things had it been properly commanded. This was emphatically evinced at the passage of the Granicus, where its gallant conduct attracted the admiration of every officer in the Macedonian army, from the king to the humblest dilochite in the ranks.[2] Notwithstanding the absurd principle upon which it was formed, and the total want of support, owing to the treachery or terror of the Greeks in the pay of Darius, who had been brought forward to sustain it, this cavalry bravely disputed the passage; drove Ptolemy, who commanded the vanguard of the Macedonian army, back into the river; charged the heads of the columns as they successively ascended the bank in order to deploy, with the utmost impetuosity; and maintained the combat until it was attacked by the formidable phalanx in front, and by the light infantry on both flanks, when it was at length forced to retire.[3] The Persian infantry had none of the qualities for which the cavalry was distinguished, and seems, in fact, to have been little better than a military mob, without coherence or solidity; while the vast numbers of this arm which were commonly brought into the field impeded the action of the cavalry, which they were incapable of supporting, and served only to create confusion, and supply food for the slaughter, when opposed to disciplined armies commanded by men conversant with military combinations. Marathon, Platæa, and Mycale, all bear witness to the truth of this observation. The war-chariots formed another source of disorder and weakness. Their number, like that of the infantry, was excessive; and as these vehicles could only act upon level ground, they were altogether useless and unavailing in a broken country, or against a skilful commander. With regard to the numerical strength of the Persian armies, we have no precise information, and can only form a conjecture from the statements, almost always exaggerated, of the Greek historians as to the numbers actually brought into the field. Xerxes, who had taken by descent a hereditary hatred of the Greeks, invaded Europe, it is said, and entered Greece at the head of an army, which, with its retinue of servants, eunuchs, and women, amounted to upwards of 5,000,000 of souls; a statement which, if true, would imply that the Persian nation had risen *en masse* to overrun the countries of the West. Yet this vast multitude, or rather horde, was arrested in its progress by 300 Spartans at the pass of Thermopylæ; and that mountain gorge would have become the scene of its total defeat and destruction, had not a base Trachinian betrayed this devoted band of heroes, and enabled the Persians to attack it at once in the front, the flank, and the rear. At Marathon, Datis and Artaphernes, lieutenants of the Great King, brought into the field 100,000 foot and 10,000 horse,[4] which were beaten by 10,000 Athenian infantry and 1000 Platæan auxiliaries, commanded by Miltiades. At Platæa, the Persian force, consisting in all of 300,000 men, was again defeated with great loss by a handful of Lacedæmonians and Athenians under Pausanias. And at the battle of Mycale, fought on the same day with that of Platæa (22d September 479 B. C.), 100,000 men, the wrecks of that portion of the army more immediately under the command of Xerxes, which had just returned from the unsuccessful expedition to Greece, were completely overthrown and dispersed by a small body of Greeks, who stormed their entrenched camp, slaughtered several thousands, and carried off an immense booty. On comparing these various numbers, and making due allowance for casualties, it would appear that the Persian monarch must have entered Greece with about 600,000 fighting men; an enormous force numerically considered, but not too great to provoke incredulity, when we reflect on the mode in which the eastern nations have always made war, and further take into account the circumstance, that nearly the whole of one reign and part of another were consumed in making preparations for this ill-fated expedition.

Of the state of the Persian army in the reign of Alexander, Arrian has furnished us with many important particulars, especially in his account of the battle of Arbela, which is the more interesting, as it gives us some insight respecting the Persian tactics under the last Darius. According to this writer, who had consulted the memoirs of Ptolemy, one of Alexander's generals, but who, nevertheless, seems to have possessed the Greek talent for exaggerating numbers, the army which Darius brought into

[1] The achievements of Cyrus, like those of Sesostris, have been so exaggerated by historians, and embellished by fabulists, that almost every grain of truth has to be separated from a bushel of fiction. The Cyropædia is merely a philosophical romance, with no more of truth or fact in it than is sufficient to give verisimilitude to the story.

[2] The Persian cavalry, 30,000 strong, was, on this occasion, commanded by Memnon, who drew it up in a single line of equal extent with that occupied by the Macedonian army on the other bank of the river. The ground on which it was posted sloped gradually towards the bank of the Granicus, which was here steep and difficult, and hence no position could have been chosen more favourable for the effective action of such a force. But its energies were paralysed, or, which comes nearly to the same thing, its full capabilities were never brought into play, in consequence of its linear formation, which admitted only of detached efforts, without *ensemble* or support. (Guischardt, *Mémoires Militaires sur les Grecs et les Romains*, tom. i. p. 251–258. Lyons, 1760.)

[3] Guischardt, *ubi supra.*

[4] The total number of Persians engaged at Marathon was, according to Valerius Maximus (l. v. c. 4), 300,000; according to Justin (l. ii. c. 9), double this amount, or 600,000 men. No attention whatever is due to such extravagant exaggerations.

Army.

the field on this occasion consisted of 1,000,000 infantry, 40,000 cavalry, 200 chariots armed with scythes, and 15 elephants; a statement which appears equally incredible, whether we regard the absolute amount here assigned, or attend to the glaring disproportion between the relative numerical strength of the different arms. Quintus Curtius, who reduces the infantry to 600,000, and raises the cavalry to 145,000, exaggerates at least with method, and thus avoids an objection fatal to the numerical accuracy of the military historian. The disposition of this enormous force, as described by Arrian, shows the incongruous elements of which it was composed. According to the custom of the Persians, the king placed himself in the centre, having around him his relations and the officers of his court, with his ordinary guards, foot and horse, which sometimes amounted to 15,000 men. These he supported by a body of Greeks in his pay, upon whom he placed great reliance, and by other *corps d'élite* furnished by the native army. The Persians, the Susians, and the Candusians composed the left; on the right were the Syrians, the Assyrians, and other nations, subjects or allies of Persia; and the whole was formed into squares or masses of prodigious depth, evidently with the intention of resisting the compact formation of the Macedonian phalanx, of which the Persians had already had woeful experience. These different nations were variously armed, some with missile weapons, others with pikes, hatchets, maces, &c.; and cavalry were stationed in the intervals between the squares. The reserve was composed of those for whom no place could be found in the first line; and being drawn up too close to it, served only to augment the confusion. The infantry of the left was flanked by the main body of the Persian cavalry, and part of that of the Bactrians; together with two corps, one Scythian and the other Bactrian, a little in advance. On the right, the Armenian and the Cappadocian cavalry were posted in a similar manner, though not in equal force. Two hundred armed chariots were drawn up before the left, and fifty before the right of the infantry, while the elephants and fifty more chariots were placed in advance of the centre.[1] Such was the disposition of the army of Darius on this memorable and decisive day. It was doubtless bad in many respects, particularly in the disproportionate crowding of all arms on the centre and left, while the right was left comparatively weak and uncovered; but its greatest defect, inseparable, perhaps, from the heterogeneous composition of the army, consisted in this, that the defeat of any one part of the line was certain to throw the whole into irretrievable disorder, and to end in a complete rout. Still it showed very considerable knowledge of the military art; while the battle which followed, and which was bravely contested, is even yet considered a study for tacticians.

The Greek armies.

From the earliest times, the genius of the Greeks, adventurous and free, inclined them to war. This, at first a consequence of their position, became in time an attribute of the national character, and gave rise to institutions which, in their turn, served to diffuse and confirm the spirit in which they had originated. Divided into a number of petty states, which were separated often by imaginary boundaries, and naturally jealous of one another, Greece was a scene of never-ending contention, and the theatre of almost continual war. New causes of difference, in the shape of injuries, encroachments, or insults, real or imaginary, were incessantly arising; and as each state was alike proud of itself, suspicious of its neighbours or rivals, and, above all, watchful of its independence, the wrong done, or believed to have been done, was promptly followed by retaliation, which again provoked a repetition of the offence, and thus led ultimately to war. Such a state of things naturally fostered a warlike spirit, and gave birth to military institutions; while the necessity of self-defence, still more than the love of conquest or of glory, rendered it imperative that every citizen capable of bearing arms should be ready to appear in the field at the call of his country. But experience soon taught the important lesson that numbers did not constitute strength, and that a small body of men prepared by early training for the duties of war, and subjected to a system of regular discipline, were capable of contending, on equal terms, with great numerical odds. When this discovery was first made, we have no means of ascertaining precisely; but it is one which must early have occurred to the rulers and governors of small states like those of Greece, the scanty population of which imposed upon them the necessity of devising the best means for rendering its disposable strength effective and available. Hence we find, that one great object of the early statesmen and legislators of this country was to organize a system of physical and moral education adapted to its peculiar position and circumstances; to engraft the military spirit on those institutions which were destined to form the general character of their countrymen; and, amidst the pursuits of peace, to prepare the minds and bodies of their citizens for encountering the fatigues, privations, and perils of war. Nor did their labours prove fruitless or vain; for the institutions thus prepared being suited alike to the genius and condition of the people, soon struck their roots, as it were, into the soil, and ere long produced those fruits which have for ages been the wonder and admiration of mankind. But less perhaps of this wonder and admiration is due to the bravery of the Greeks, eminent as it always was, than to their discipline, organization, and conduct in the field. Among them all the branches of the military art were simultaneously cultivated, and received the most important improvements. Their formation was rendered compact and formidable; combining solidity and the power of resistance, with a mobility which made these qualities available on different points, even in action. Their tactics were singularly adapted to the peculiar character of their troops, and were founded on the most certain principles of the art.[2] And, in later times, we find strategy recognised and taught as a science in the schools;[3] while, in the field, it received, in several respects, a development which no other nation, ancient or modern, has yet been able to surpass. Lastly, we may observe, that until the reign of Philip, the father of Alexander the Great, Greece had no standing army. Her strength consisted in her militia; and to this description of force she was indebted for the imperishable glories of Marathon, Platæa, and Mycale, when the myriads of the Persian invader were successively overthrown. But, from the causes above indicated, and the incessant contests in which the different states were engaged with each other, this militia had acquired the principal characteristics of a regular force, both as regards

[1] Guischardt, *Mémoires Militaires sur les Grecs et les Romains*, tom. i. p. 260–61.

[2] Guibert, in his *Discours Préliminaire*, part second, underrates the tactics of the Greeks. "Je compare les guerres des Grecs," says he, "et la plupart des guerres des anciens, à celles de nos colonies dans l'autre continent. J'y vois cinq ou six mille hommes les uns contre les autres, des champs de bataille étroits, où l'œil du général peut tout embrasser, tout diriger, tout reparer. *Un bon major conduiroit aujourd'hui la manœuvre de Leuctre et de Mantinée, comme Epaminondas*," p. 82. It will be fortunate for modern armies when their "good majors" are as skilful and as brave as Epaminondas.

[3] Guischardt, *Mémoires Militaires*, tom. ii. p. 155.

Army. organization and discipline, and consequently was of nearly equal avail against an enemy in the field.

The Spartan army. To the institutions of Lycurgus Sparta was indebted for her military pre-eminence among the states of Greece. To exclude all refinement and luxury, to cultivate the sterner virtues of abstinence and self-denial, to inure the body to hardships and the mind to suffering, to inculcate self-sacrificing patriotism, and to form great characters, appear to have been the principal objects of this iron-hearted legislator; who accordingly laid the foundations of his institutions in a system of primary education, intended and calculated to convert the free male population of the state into a military community, and to develope to the utmost all those physical and moral qualities which render men invincible in war. Nor did the results disappoint the calculations upon which this system had been founded. Trained from their earliest years to suffer the extremes of heat and cold, hunger and thirst, to endure pain with unflinching fortitude, and to despise danger and death; habituated to the most implicit and unquestioning obedience to all placed in authority over them; and continually exercised in running, wrestling, swimming, ball-playing, and martial games of all sorts, as well as in stratagems, surprises, and ambuscades; the Spartan youth, when called to take the field, were prepared at once to enter upon the duties of war with alacrity and vigour, and to regard with indifference all the privations and fatigues of the severest campaign. Nor were their discipline and organization inferior to their military qualities. The Spartan phalanx, which formed the basis of the Macedonian, consisted of eight files in depth.[1] The files were placed at intervals of six feet from one another when disposed in open order; in close order the distance was three feet; in locked order one foot and a half; the intervals being thus diminished one-half at each approximation. The open order was that observed on the march, and in evolutions or manœuvres; the close order was for the attack; and the locked order was that in which an attack was received. The front rank consisted of picked men; the rear rank was also select; while those upon whom least dependence could be placed had their station in the centre, in order to give impetus and momentum to the column by their weight and physical power. The different parts of the phalanx were classed according to a regular system, and, in particular, the covering file was matched in quality as nearly as possible with the file in front; so that if the whole or any part of the front rank failed, the vacancies were supplied by the second files, without disordering the line. The arms, offensive and defensive, of the soldier, consisted of a spear or pike, a short sword or dagger, and a shield or buckler of an oval form, which was fastened round the neck and at the left shoulder by means of straps. But latterly Cleomenes changed this clumsy encumbrance for the Macedonian shield, originally invented by the Carians, which was fastened on the left arm by a ring or belt, so as to leave the soldier free to employ both hands in giving force and direction to the pike. The Spartans were also familiar with the most approved evolutions, which they performed with equal celerity and precision. The rear of the phalanx became the front, or the front the rear, by the shortest and simplest operation; while, by redoubling its formation, it became a solid square, bristling on every side with pikes, and, in locked order, wholly impenetrable to attack, except upon broken ground. Rapid changes of front even in the presence of an enemy, refusing or advancing a wing at a critical moment, turning an enemy's flank, and many other manœuvres, which are still considered equally delicate and difficult, were frequently executed with the most complete success by the commanders of these formidable columns. In a word, the Spartans may be regarded as the founders and first improvers of that military system, which attained its perfection under Alexander, and placed the crowns of Asia at his feet.[2]

The Athenian army. The Athenian military force consisted of three classes; first, the heavy troops, ὁπλῖται, armed with a spear, a dagger, a cuirass or corslet, and an oval shield, and reserved for the phalanx or main battle; secondly, the light troops, πελτασταί, armed with a light spear, a javelin, and a target, and destined for skirmishing, seizing or maintaining positions, and covering the movements of the phalanx; thirdly, irregular troops, γυμνῆται, without defensive armour, but provided with missile weapons, such as javelins, bows and arrows, and slings, for harassing an enemy on his march, or performing the duties of light troops in the field.[3] The phalanx or main battle consisted entirely

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[1] There is some confusion among the ancient writers on the subject of the division of the Spartan force. Thucydides, describing the arrangement and proportions of the Spartan army at Mantineia, informs us that a battalion or *lochos* consisted of four *pentecosties* or companies, a pentecostie of four *enomoties* or platoons, and each *enomotie* of 32 men; thus making the whole strength of the battalion 512 men. But he makes no mention of the number of battalions in a regiment, and indeed acknowledges that the subject was obscure, and his information imperfect. According to Xenophon, the Spartan *mora* or regiment consisted of four *lochi*, the lochos of two *pentecosties*, and the pentecostie of two *enomoties*. The number included in the last denomination is not given; but, if we assume that it consisted of 32 men, as stated by the historian first named, the regiment of Xenophon would amount to 572 men, or 50 more than the battalion of Thucydides. How are these discrepancies to be reconciled? It is scarcely probable that the division of the Spartan force underwent any change in the interval between the time of Thucydides and that of Xenophon; but it is very probable that neither may be correct, considering that the Spartans studiously concealed from the observation of foreigners the internal organization and strength of their armies.

[2] The Spartan phalanx advanced to meet the enemy's at a regular step, in accord with the cadence of military music, and, even when beaten, generally retired from the field in perfect order, however reduced in number. After battle, every soldier was obliged to produce his shield, as a proof that he had fought, or retired, as a soldier ought to do, bravely and steadily. If he had lost or thrown away his shield he was disgraced for ever; the brand of indelible infamy was fixed upon him. But this was of rare occurrence; for the love of military glory was the only passion which the Spartan people were allowed to cherish; and both education and discipline had combined to eradicate fear from their bosoms. It was a word unknown in their vocabulary. In this singular country all passions merged in one. The Spartan mother and the Spartan wife rejoiced when a son or a husband had fallen honourably in the field of battle, and sometimes refused to recognise as of kindred with themselves such of their relatives as had survived a defeat. The only mourners on account of the disaster at Leuctra were those whose friends and kinsmen had escaped the slaughter of that bloody day.

[3] These classes may be considered as analogous, the first to the grenadiers, the second to the light infantry, and the third to the riflemen or sharpshooters of modern armies. Their armour, however, was different at different times; for the Greeks, like the Romans, made several changes in this respect; and hence the apparent discrepancies which we meet with in the accounts of historians. For example, when Arrian mentions the militia of the ancient Greeks, he speaks of the times which preceded the constitution and organization which Philip and Alexander the Great gave to their troops. The oval buckler, larger than common, and the long pike or *sarissa*, were introduced by these sovereigns, and found to add incalculably both to the defensive and offensive power of the phalanx. Some of the Greeks, however, piqued themselves on not adopting the changes of Alexander; but Philopœmen at length persuaded the Achæans to lay aside their ancient arms, and assume those of the Macedonians.

of natives of Attica, and was drawn up according to tribes or communities, probably with the view of exciting a generous rivalry in deeds of arms. The light armed troops were partly native and partly foreign; the slingers and archers were wholly foreign. The cavalry, like the heavy-armed infantry, consisted of natives alone, and were of a good description, being remarkably alert, intelligent, and enterprising. Thus composed, the Athenian army was prepared for every species of warfare, and equal to the most arduous achievements. The intelligence, activity, quick perception, and daring spirit of enterprise for which the native of Attica, the Frenchman of Greece, was distinguished, rendered him formidable in desultory warfare, alert in his movements, and prompt in taking advantage of every favourable circumstance; insomuch that the Athenian light troops foiled, and on some occasions even discomfited, the renowned Spartan phalanx. The Athenian phalanx was less compact than that of Sparta, and, owing to the character of the people, as much perhaps as to its formation, less adapted to receive and repel an attack; but in the charge it was perfectly irresistible. Its onset was terrible, and overthrew all before it. The cause of this must be sought in the difference of national character. The Spartan was chiefly celebrated for his passive, the Athenian for his active courage. Hence the one was powerful in resistance; the other formidable in attack. The Spartan was steady, devoted, and firm; the Athenian bold, enterprising, intelligent, and full of address and dexterity. If the one was less capable of resistance, the other was more ardent and impetuous; their military qualities were as opposite as their natural characters, but both were admirable of their kind; and if it had been possible to combine them together in equal proportions, perfect soldiers might have been formed, and a perfect army organized. The Athenians, we may observe, were the first of the Greeks who advanced upon the enemy at an accelerated pace corresponding to what is now called double-quick time. This innovation was first introduced by Miltiades at Marathon, in order to give increased momentum to the charge which he directed against the Persian masses; and it was consecrated in Athenian tactics by the glorious result of that ever-memorable day.[1]

The Macedonian army.

But the very principles which had saved the states of Greece from foreign invasion, and enabled them to maintain their independence, were destined to form the basis of a military establishment, more formidable, because more complete in all its parts, than any which that or other countries had yet produced, and organized for the express purpose of serving as an instrument for subverting Grecian liberty. We allude of course to the Macedonian army in the reigns of Philip and his son Alexander the Great. The founder of this establishment, Philip of Macedon, was a man of unquestionable talents, of convenient principles, and of boundless ambition. Having improved his natural parts by associating with the scholars, statesmen, and philosophers of his age; and having been initiated into the scientific principles of the art of war under Epaminondas, the most celebrated master of the time; he was early fired with a love of military glory, and a lust of conquest and dominion. But although the brilliant period in the annals of the Greek states was past when Philip made his appearance, and these communities had already begun to show symptoms of decline, enough of the ancient spirit still remained to convince him, that, without creating new means, and organizing a force different from any which had yet existed, he could never hope to realise his ambitious projects, by rendering himself the master of Greece. The sagacity of Philip was fully on a level with his ambition. He saw that in the rude shepherds and hunters of Macedonia might be found the raw material of an army; that discipline and organization were alone wanting to convert this material into an invincible force; and that to render a military force completely effective, or, in other words, to derive from it the utmost benefit it was capable of affording, it was indispensably necessary to depart from the militia system which had hitherto prevailed, and to start from the principle that no army could be good which was not permanent. He was thus the first who fully comprehended the importance of a standing army, both as regards the efficiency of a military body itself, and also with reference to projects of conquest or ambition; and he may further claim the distinction of having been the first to organize a permanent force. In prosecuting this design he showed a skill, and a knowledge of the principles of military organization, equal to the sagacity evinced by its conception. Adopting the Spartan phalanx as the basis of his system, he gave it greater depth and solidity, so as to render it irresistible in the attack, and impenetrable when drawn up in position. He changed or improved its armour both for offence and defence; and, in particular, introduced the large oblong buckler, and the *sarissa* or Macedonian pike, the most formidable weapon of ancient times. The light-armed troops were also placed on a better footing than they had ever before been among the Greeks, being formed in demi-phalanges, which, without materially lessening their mobility, rendered them capable of combining their efforts in an effective manner with those of the heavy-armed infantry. The equipments, arms, and discipline of his cavalry were in like manner improved, and their organization perfected, with the utmost care and diligence. In a word, all that was excellent in the different Greek systems was combined in the Macedonian; while their defects were avoided, and improvements introduced wherever these seemed to be either expedient or necessary. Such was the general character of the military establishment which Philip created for enabling him to trample on the liberties of Greece, and which Alexander employed in subjugating the world. We shall now speak of its different parts in detail.

The phalanx was composed of files of a certain depth, and of regular combinations of those files. The *lochos* or file was a number of soldiers ranged in line, one behind the other, from the head to the *serre-file* or *ouragos*. The file consisted at different times of different numbers of men, as eight, ten, twelve, and sixteen. Alexander chose the last, because it formed the best proportion relative to the extent and depth of the phalanx; nor did it prevent the archers and slingers, stationed behind, from launching their missiles at the enemy, over the heads of the phalangites. If the phalanx was doubled to form a solid column, or reduced to one half in order to extend its front, the respective depths of 32 and 8 still remained proportional; but if the original depth of the file had been only 8, as in the Spartan phalanx, the latter evolu-

[1] It is very much to be regretted that no military or scientific description has been preserved of the battle of Marathon. The accounts which have reached us, being written by men ignorant of military affairs, are meagre, confused, and unsatisfactory; containing details, indeed, of the numbers engaged, and the amount of the slain, but giving little or no information respecting the combinations and manœuvres which decided the fortune of the day. One thing only is certain,—the victory was the result of consummate generalship on the part of the commander, and of heroic valour on that of the soldier.

tion could not have been performed with safety, because it would have reduced the depth to 4, and thus deprived the formation of its peculiar characteristic of solidity. The preference given to the number 16, therefore, was on account of its divisibility, and its admitting of evolutions consistently with the nature of the phalanx, which could not have been attempted with files composed of any other number, greater or less. The best man was chosen as the head of the file, and named *lochagos* or *protostate;* the second was called *epistate;* the third bore the same name as the first, the fourth the same as the second, and so on to the last; so that each file was composed of *protostates* and *epistates*, ranged alternately from the *lochagos* to the *ouragos*, who was also a picked man.[1] The junction of two or more files was denominated *syllochism*. It was effected by placing the *protostates* and *epistates* of the one exactly opposite the *protostates* and *epistates* of the other; and one man, considered in reference to his juxtaposition with another, was called *parastate*. The junction of all the files formed the phalanx; of which, therefore, the *lochagi*, or heads of files, constituted the front rank, and the remaining *parastates* in alignement, as far as the *ouragi* or *serre-files*, the depth.

The phalanx, thus composed, was divided into two equal parts; one called the right wing or head, and the other the left wing or rear. The point of separation or division was variously denominated the navel, the mouth, and the jointure of the phalanx. And as the principle of this formation was, that every combination should be divisible into two equal parts, so the phalanx, as finally constituted by Alexander, was composed of 16,384 heavy-armed men, the half of which number was considered sufficient for light troops, and the half of that again, or the fourth of 16,384, sufficient for cavalry; while the divisibility into equal parts afforded great facility for executing with precision all manner of evolutions, and extending or diminishing at pleasure the front of an army. The total number of the phalanx being, as already stated, 16,384, and each file consisting of 16 men, it follows that there were in all 1024 files. But each combination of files had its peculiar and appropriate denomination. Two files united formed a *dilochie*, under a *dilochite;* four files, a *tetrarchie*, under a *tetrarch;* two tetrarchies, a *taxiarchie*, under a *taxiarch* or *centurion;* two taxiarchies, a *syntagma* or *xenagie*, under a *syntagmatarch* or *xenagos;*[2] two syntagmata, a *pentecosiarchie*, under a *pentecosiarch;*[3] two pentecosiarchies, a *chiliarchie;* two chiliarchies, a *merarchie* or *telarchie;* and two merarchies, a *phalanx* of 4096 men in 256 files, which was commanded by a general, under the name of *phalangarch*. Again, two phalanges formed a *diphalangarchie;* and two diphalangarchies, a *tetraphalangarchie*, or the grand phalanx, which thus consisted of two wings or diphalangarchies, four phalanges, eight merarchies, 16 chiliarchies, 32 pentecosiarchies, 64 syntagmata, 128 taxiarchies, 256 tetrarchies, 512 dilochies, 1024 files, and 16,384 men. The front might be extended by simply augmenting the distance between the files; the phalanx was closed by lessening the distances between the ranks and the files, and thus diminishing both its front and its depth. Its locked order was called *synapism*, in which the ranks and files were so closely approximated that the soldier could not turn.[4] In this formation the men at the exterior of the mass held their bucklers before them; the next rank raised their bucklers over the heads of those immediately in front of them; the third rank held their bucklers over the heads of the second, and so on; thus forming a sort of roof, over which the archers in the rear sometimes passed to the front, and which, from the bucklers being joined like the scales of a crocodile, resisted and threw off the heaviest missiles discharged by the enemy. As every thing depended on the steadiness of the heads of files and their *epistates* of the second rank, both were *gens d'élite* or picked men. When the phalanx was closed for action, each man occupied only three feet of ground in rank and file. The pikes or *sarissæ* were 24 feet in length, 6 feet being behind and 18 feet before the grasp; consequently (as the ranks were three feet separate), the second rank advanced the pike 15 feet, the third 12, the fourth 9, the fifth 6, and the sixth 3 feet; thus presenting an array of points such as never bristled along the front of any other military mass or column. The soldiers of the other ranks, as they could not employ their pikes, pushed on those before them, and, by their weight, served to augment the violence of the shock.[5] In this case every thing depended on the *serre-files* or *ouragi*, who were the keys of the phalanx, and, like the *lochagi*, picked men. Such was the Macedonian phalanx,[6] which was destined to conquer the world, and to be, in its turn, conquered by the world's conquerors. It yielded to superior tactics and greater mobility.

The light-armed infantry were drawn up in different ways, according to the nature of the ground and the dis-

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[1] Some authors designate a file *stichos*, others *decuria*. They who apply the latter epithet seem to suppose that it consisted of ten men, which is not true as respects the Macedonian file. We have followed, in the text, the nomenclature of Arrian, whose authority on this subject is decisive. With regard to the term *enomotie*, which has so much puzzled commentators, we have already shown that it means something different from a file, or part of a file. It was a term peculiar to the military system of Sparta, whence it passed into the other systems of Greece, including the Macedonian; but no data have been given from which its precise import can be ascertained.

[2] The *syntagma* or *xenagie* had four supernumerary men; a standard-bearer, an officer who marched behind and performed the duty of our major, an adjutant, and a crier to repeat the orders. This section, ranged in order of battle, formed a perfect square. (Arrian's *Tactics*.)

[3] The *pentecosiarchie* of the Macedonians answered to the *lochos* of the Spartans. This must be kept in mind in the perusal of Thucydides and Xenophon, otherwise both will be unintelligible.

[4] It was to this locked order that Epaminondas was indebted for the victories which he gained over the Lacedæmonians at Leuctra and at Mantineia. The Theban army was formed in columns of attack, upon a front considerably less than the depth. The shock, therefore, proved too much for the Spartan phalanx, which was only eight deep. Xenophon compares it to that of a heavy vessel striking a light one amidships with her bow, and dashing her to pieces by the collision.

[5] The loss of men in the day of battle, or the necessity of sending out detachments, made no change in the form and disposition of the phalanx. The sections were always kept up to their full complement of ranks and files. The effective diminution fell, not upon the ranks and files, but upon the number of the sections, which were retrenched in proportion as they filled up the void in the phalanx.

[6] The Macedonian phalanx, says Arrian, was as formidable in appearance as it was in reality; and Paulus Æmilius confesses, that, when he saw, for the first time, this imposing mass, with its front bristling with the terrible *sarissæ*, he was struck with consternation. Guischardt alleges that it was "plus terrible à l'aspect que dans l'effet;" and adds that Paulus "ne laissa pas que de la battre avec ses Romains épars et distribués en plusieurs pelotons." But if Alexander had commanded it, the Roman would have told a different tale. Guischardt has himself demonstrated that the loss of the battle of Cynocephale was mainly, if not exclusively, owing to the stupidity of Philip in committing the phalanx upon broken ground, where its flanks were uncovered, and the principal advantages of its formation lost.

position of the enemy; sometimes before the phalanx, sometimes behind it, sometimes on both wings, sometimes only on one. Their formation was in all respects similar to that of the phalanx, and their files, eight deep, were combined upon analogous principles. The Macedonian cavalry was of various descriptions, as *kataphracti*, light horse, and *acrobolistæ*. The *kataphracti* or cuirassiers were completely covered with defensive armour; the man with a cuirass and cuisses of iron scales, the horse with a frontlet and mail. Their offensive arm was the Macedonian pike. The light cavalry, unencumbered with heavy armour, carried lances and missile weapons. The *acrobolistæ* had no lances, and, like the Armenian or Turkish cavalry, used only the bow and arrow. They were a species of Cossacks or irregular horse, and performed the duties of such. The usual formation of the regular cavalry for attack was the cuneiform, which had been introduced by Philip, from an idea that it was the order best calculated to pierce an enemy's line; but they were sometimes drawn up in squares, sometimes in the form of a rhombus, and sometimes also in a line.

The numerical strength of the Macedonian, like that of other ancient armies, can only be conjectured from the numbers actually brought into the field. In the time of Philip it probably never exceeded a grand phalanx, with its proportional complements of light troops and cavalry, 28,603 in all, and a few thousands of auxiliary troops. At the passage of the Granicus, Alexander's army consisted of above 30,000 infantry and 5000 cavalry; from which we may conclude that it was composed of one grand phalanx, with its proportional complements of light troops and cavalry, and about 6000 auxiliaries. But it was afterwards powerfully reinforced; for Alexander paid great attention to recruiting, especially in Greece, and had always generals detached from the army for the purpose of raising new levies in that country. Accordingly we find that, at the battle of Arbela, the Macedonian army consisted of two grand phalanges, or 32,768 heavy armed infantry, two corps of *peltastæ*,[1] each 8186 strong, and 4096 cavalry, including the Thessalian horse, besides several thousand auxiliaries, chiefly irregular troops; thus making a grand total, including auxiliaries, of at least 60,000 fighting men, or 54,000 regular and 6000 irregular troops.

It has been supposed by some that this army, like that of Carthage, was heterogeneous in its composition; that men of all nations were to be found in its ranks; and that a stern, unrelaxing discipline constituted the only *vinculum* or tie by which the naturally discordant mass was held together. There cannot possibly be a greater mistake. The Macedonians, it is true, formed but the nucleus, as it were, of the army; and, both in the reigns of Philip and Alexander, recruits were obtained in considerable numbers from the neighbouring states of Greece. But whatever shades of difference might have been produced by local circumstances and diversity of institutions, the inhabitants of all these states were essentially one and the same people; identical in origin, distinguished by like peculiarities physical and moral, and possessing a general national character. In what respects, then, can the Macedonian army be considered heterogeneous? None but Greeks were admitted into the ranks of the phalanx, or those of the light infantry and cavalry; no barbarians were received even as auxiliaries. It was composed exclusively of people of the same country and the same general character, who all spoke dialects of the same language, shared a common temperament, and were distinguished by their physical configuration, no less than by their intellectual and moral attributes, from the inhabitants of the surrounding nations. If ever there was an army, therefore, which discipline could render more completely homogeneous than another, it was that of Macedon during the reigns of Philip and Alexander; nor do we know of any modern army to which this epithet can with equal justice be applied. The British army is composed of English, Scotch, Irish, Welch, and Highlanders; the French, of Bretons, Normans, Gascons, Alsatians, Savoyards, and many other tribes; the Austrian, of Hungarians, Bohemians, Transylvanians, Croatians, and Germans; the Prussian, of Silesians, Saxons, Poles, Pomeranians, and Brandenburgians; and the Russian, of Muscovites, Poles, Sclavonians, Tartars, Circassians, Armenians, and innumerable other races; yet all these are considered national armies, and have each, in fact, a national character. But if such assemblages are to be regarded as homogeneous, we know not upon what principle the Macedonian army, composed exclusively of Greeks, can possibly be viewed in a different light, or supposed to have had no other bond of union than what was created by discipline alone.

The Theban and Achæan armies.

The only other Greek armies which seem to require notice are those of the Thebans and of the Achæan League. The Theban army, like Theban independence, may be said to have been created by Epaminondas, and to have expired when that great captain fell in the arms of victory upon the field of Mantineia. Still it is a striking example of what genius and discipline may effect, even when called to work upon the most unpromising materials. Epaminondas found it a rabble, and he left it the most formidable military force which Greece had ever yet known. He gave it that organization which rendered it victorious at Leuctra and Mantineia, and which shook to the very foundation the power of the Lacedæmonians. Aware that the Spartan phalanx was invincible by any similar formation, and that he could only hope to prevail by bringing against it a greater concentration of physical energy, he organized the Theban army in columns upon a front less than their depth, so as to enable him to direct the whole or any part against a given point of the enemy's line, and to bear it down by an irresistible superiority of force; and he adapted his tactics to this organization. At the battle of Leuctra, accordingly, Epaminondas, observing the Lacedæmonians advance their two wings before the centre, so as to form the order which the Greeks called the half-moon, instantly attacked the centre of one of these wings, and, having penetrated it, soon succeeded in throwing the whole into irretrievable confusion. Here the onset was made by one wing in column against another in comparatively open formation; and hence the Theban order of attack became the oblique, which is erroneously supposed to be a discovery of modern times. At Mantineia the Lacedæmonians carefully avoided the blunder for which they had paid so dear at Leuctra, and kept their forces more concentrated; but Epaminondas, forming the whole of his infantry in a single column, precipitated it upon a part of the enemy's line, overthrew it, and thus decided the fortune of the day. The Theban army, immediately after the battle of Leuctra, is said to have amounted to 50,000 men. This, however, is probably an exaggeration.—With regard to the army of the Achæan League, it continued insignificant for

[1] For an able and learned account of the *peltastæ*, who sometimes formed considerable bodies, particularly in the armies of Alexander and his successors, and whose reputation almost equalled that of the phalanx itself, see Guischardt's note to his Translation of Arrian's *Tactics*, in the second volume of his *Mémoires Militaires*, p. 177.

the greater part of a century after that celebrated confederacy was entered into. Aratus was the first who placed it on a respectable footing, and taught it to conquer at Caphyæ; and he was succeeded by Philopœmen, incomparably the most scientific commander of ancient times, who completed its organization, and led it to victory at the second battle of Mantineia, where the Spartans, under Machanidas, were completely defeated, and the tyrant himself slain by the hand of the Achæan chief. This victory was exclusively owing to the superior tactics and dispositions of Philopœmen; who, instructed by the successes of the Romans, had contrived, with infinite skill, to combine, in the formation and arrangement of his troops, the advantages of the legionary order with those of the phalanx. The invaluable fragment of Polybius, containing a description of the battle of Mantineia, gives no account of the numbers engaged. We learn, however, that Philopœmen having assembled the troops of the League, spent eight months in perfecting their discipline and organization before he ventured to commit them in the field against so experienced and warlike an enemy as the Spartans.[1] An army is a piece of mechanism which only acts effectively when all the parts are combined and adjusted together so as to insure the most complete concert and unity of operation; and discipline is the mean by which this important result is produced. It is in fact the art of creating a new power; and so great is its efficacy that it sometimes developes in men those qualities which it only professes to direct and regulate.

The Carthaginian army.

This remark is strikingly exemplified in the history of the Carthaginian army. That army was almost entirely composed of mercenaries, or at least of levies drawn from countries differing in language, in manners, in customs, and in character. In its ranks were to be found Africans, Spaniards, Gauls, Boians, Insubrians, Etruscans, and various other races; yet such are the fusing effects of discipline, that this apparently heterogeneous mass vanquished the Romans on the Ticino; overthrew their legions in three pitched battles, at Trebia, Thrasymenus, and Cannæ; and, if Hannibal had known how to profit by victory, might have planted the Carthaginian standards amidst the ruins of Rome. The advantages of a truly national army are great, especially in reverses: it may be beaten, but cannot easily be destroyed: and even its disasters may teach it that experience which will ultimately conduct it to victory; as happened to the Romans in ancient, and to the Russians under Peter the Great, in modern times. But, on the other hand, many instances might be produced to show, that the most effective armies may be organized out of the most discordant and unpromising materials; and that, while nothing can supply the want of discipline, discipline can almost atone for and remedy every thing. With an army composed as we have already described, Hannibal maintained, during sixteen years, the war against the Romans in Italy, without sustaining any serious reverse; nor did he withdraw, until his presence was rendered necessary for the defence of his country; which the successive defeats of the other Carthaginian commanders, both by sea and land, had uncovered, and exposed in its turn to the attacks of an invader. Finally, he was vanquished at Zama from the same cause which had rendered him so often victorious—namely, superiority of discipline: for although his military genius never shone forth more transcendently than in his last field, and although his dispositions were in all respects worthy of his high reputation, yet the raw and undisciplined levies which formed the strength, or rather the weakness, of his army, were in no condition to contend with the Roman legions, whom sixteen years of incessant warfare had improved both in discipline and experience.[2] In reflecting upon the issue of this decisive conflict, which terminated the long and sanguinary struggle between the rival republics of Carthage and Rome; and, above all, in considering the precarious nature of that power which is built on the uncertain foundation of military glory; the mind insensibly passes from the contemplation of the fate of the Carthaginian chief to that of a still greater commander, which in some measure resembles it—from the days when these warlike republics contended for the empire of the world, to our own times, when, in a new field of Zama, another Scipio conquered another Hannibal.

With regard to the numerical strength of the Carthaginian army, it appears to have varied at different times. The force with which Xantippus defeated Regulus, and made him prisoner, did not probably exceed 20,000 men; and we learn incidentally that the heavy-armed infantry which the Lacedæmonian had formed in phalanx, conformably to the tactics of his country, amounted to between 8000 and 9000 men, and were all native troops. But when the Carthaginians afterwards invaded Spain, they recruited their armies from the population of the country, and that of the neighbouring provinces of Gaul, until the total numerical strength of these must have considerably exceeded 100,000 men. Livy assures us that Hannibal set out on his expedition to Italy at the head of 100,000 foot and 10,000 horse, but that he lost 30,000 men in crossing the Alps; so that, according to the Roman historian, he must have entered Italy with about 80,000 men. But the numbers actually brought into the field completely disprove this statement: for it is admitted by Livy himself that, at Trebia, Hannibal had only 30,000 infantry and 10,000 cavalry, and that he vanquished at Cannæ with 40,000 foot and 10,000 horse. We shall be nearer the truth, therefore, if we suppose that the invasion of Italy was undertaken with little more than half the number of troops mentioned by Livy; and that the losses sustained in crossing the Alps were, in a great measure, repaired by the recruits which Hannibal drew from the Boians, Insubrians, and his other allies; a supposition which seems completely borne out by the authority of Polybius. But when the Carthaginian general set out from New Carthage for Italy he left two other armies in Spain; and, if we assume these to have been each about 30,000 strong, while the force under his own command exceeded 50,000, it will follow that, at this time, the Carthaginians had considerably more than 100,000 men of all arms in the field.—Let us now attend to the composition and organization of that strictly national force with which these well-disciplined condottieri were called to contend, and by which, after sustaining many reverses, they were ultimately overthrown.

The Roman army.

The army of Rome, in the days of her conquests, was perhaps the most perfect, certainly the most formidable, which the world had yet seen; and the superiority which it ultimately obtained over the military force of every nation to which it was opposed, seems to have been exclusively owing to the pre-eminent excellence of its discipline and organization. "Nulla enim alia re videmus populum Romanum orbem subegisse terrarum," says Vegetius, "nisi armorum exercitio, disciplina castrorum, usuque militiæ. Quid enim adversus Gallorum multitudinem paucitas Ro-

[1] See Guischardt's commentary on this battle, *Mémoires Militaires*, tom. i. p. 177.

[2] We must again refer to Guischardt, tom. i. p. 216, more especially as this very able military commentator exposes the misrepresentations of Folard, who seems to have been alike incapable of comprehending the narrative of Polybius, or the dispositions of Hannibal.

mana valuisset? Quid adversus Germanorum proceritatem brevitas potuisset audere? Hispanos quidem non tantum numero, sed etiam viribus corporum nostris præstitisse, manifestum est. Afrorum dolis atque divitiis semper impares fuimus. Græcorum artibus prudentiaque nos vinci, nemo unquam dubitavit. Sed adversus omnia profuit tyronem solertem eligere, jus (ut ita dixerim) armorum docere, quotidiano exercitio roborare, quæcunque evenire in acie, atque in prœliis possint, omnia in campestri meditatione prænoscere, severe in desides vindicare. Scientia enim rei bellicæ, dimicandi nutrit audaciam. Nemo facere metuit, quod se bene didicisse confidit. Etenim in certamine bellorum, exercitata paucitas ad victoriam promptior est: rudis et indocta multitudo, exposita semper ad cædem."[1] The military age was seventeen; and, when the exigencies of the state required it, every citizen, from seventeen to forty-six, or even fifty, was obliged to enrol himself as a soldier. Except on pressing emergencies, however, the more youthful part of the population was preferred, as that which could be most effectually trained to the exercises and formed to the discipline of war.[2] These were of the most severe description, and had for their object not merely to instruct the soldier in the use of arms, in marching, and in evolutions, but to develope and improve to the utmost his physical powers; to inure him to labour, fatigue, and hardships of all kinds; to qualify him for surmounting with ease the various obstacles and difficulties incident to a state of active warfare; to give precision and rapidity to his movements; and, above all, to create that confidence in himself, and that unbounded reliance upon the efficacy of order, subordination, and combined action, which nourish audacity, yet temper it with coolness and steadiness. Besides the use of arms, of which we shall hereafter speak, the young soldier was, accordingly, trained to the exercises of running, leaping, vaulting, wrestling, and swimming, armed as well as unarmed: he was required to perform long and frequent marches, at the rate of four miles an hour, carrying a load of sixty pounds weight: he was carefully instructed in the use of the tools necessary for throwing up all manner of field-works, particularly fortifying the camp: and, even after he had been found qualified to join the legion, he was constantly employed, while in camp, either in the practice of these manly exercises, or in acquiring greater dexterity and precision in the use of his weapons. The Roman soldier knew no intervals of idleness, and was not allowed time to indulge in dissipation. The camp was his home: war was his business: its exercises formed his amusement: its success constituted his glory. In the legion to which he belonged were concentred all his hopes, all his thoughts, and all his affections.

In raising troops to constitute the legions, the method adopted by the Romans was that which they denominated *election;* because the magistrates chose from the different tribes the citizens whom they considered best fitted for the military service. The consul or the prætor assembled in the Campus Martius, or in the Capitol, all the citizens, who were bound to concur in the formation of the legions, raised every year, conformably to a decree of the senate; and this obligation included all Romans within the age above specified, who had not served twenty campaigns as foot soldiers, or ten campaigns as horsemen or knights; with the exception, however, of the lowest class, which was exempted from military service on account of its poverty. The number of legions commonly raised was four;[3] and the first step consisted in the appointment, either by the people or the consuls, of six tribunes to each legion. The conscripts being classed according to their tribes, the magistrate, charged with the levies, then elected four successively from each tribe. Of every four thus designed the tribunes of each legion in their turn chose one, whose name was immediately inscribed in its muster roll; and this operation, which established a perfect equality in the composition of the legions, was repeated until they had received their proper complement of men. On the termination of the election each legionary individually took the *sacramentum* or military oath; swearing to be obedient to his general, and to execute his commands in all things to the utmost of his power and ability. Nor was this a vain ceremony; for the Romans, trained up in the fear of the gods, had a peculiar reverence for the sanctity of an oath. Roman citizens alone were admitted into the legions, until the time when the civil wars led to the subversion of the republic, and the violation of all established rules. Those, however, who had completed the prescribed period of service, or had attained their fiftieth year, were no longer obliged to take arms in defence of the state, and were only liable to be called out in the event of the city being threatened with some imminent danger. But these brave veterans, habituated to a military life, frequently inscribed themselves as volunteers, and thus served both as models and examples to the young legionaries, who seldom failed to profit by their experience, and generally showed an ambition to come up to their standard.

As soon as the military oath had been administered, the tribunes dismissed the legionaries, having first indicated the time and place where they were afterwards to assemble in order to be embodied. At the general muster, on the day fixed for this purpose, the youngest and poorest in each legion were selected as *velites;* the next in order were chosen as *hastati;* the class immediately above constituted the *principes;* and the *triarii* were formed of the oldest and richest citizens elected to serve in the legions; the different classes being thus arranged according to their arms, their fortune, and their age. The legion was commonly composed of 1200 *hastati*, 1200 *principes*, 1200 *velites*, 600 *triarii*, and 300 cavalry or knights; thus making its total

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[1] Vegetius, *De Re Militari*, l. i. c. 1. Raphengii, 1607.

[2] "Adolescentes legendi sunt, sicut ait Sallustius: nam primum juventus, simul ac belli patiens erat, in castris per laboris usum militiam discebat. Melius enim est, ut exercitatus juvenis causetur ætatem nondum advenisse pugnandi, quam doleat præteriisse. (Vegetius, l. i. c. 4.)

[3] A consular army consisted of two legions, and of a certain number of troops furnished by the *socii* or allies of Rome. The infantry of the allies, according to Polybius, did not surpass in number the legionary infantry in a consular army, but their cavalry was double the number of the knights. The fifth part of their infantry and the third part of their cavalry formed a *corps d'élite*, called *extraordinary* or *elect*, under the immediate orders of the consul; while the remainder of the social troops were divided into two corps, one called the right and the other the left wing. Hence a consular army consisted, in Roman troops, of 6000 legionaries of the line, 2400 *velites*, and 600 knights; in social troops, of 6700 infantry of the wings, 1700 extraordinary infantry, 800 cavalry of the wings, and 400 extraordinary cavalry; making a total of 18,600 men. But when Rome had a difficult war to carry on, two consular armies were raised, and both the consuls took the field; which, in fact, happened almost every year. Lastly, when urgent circumstances required it, the consular armies were doubled and united in order to contend with a formidable enemy. Thus the Romans assembled at Cannæ four consular armies, or nearly 80,000 men, to try the fortune of arms against Hannibal; and, in the heat of the second Punic war, they raised as many as twenty-three legions, or considerably more than 100,000 men. "Alors," says Rogniat, "les armées se multiplièrent en raison de ce grand nombre de légions; les deux consuls choisissaient celles qui leur convenaient, et le commandement des autres était confié à des préteurs, à des proconsuls, et à des propréteurs." (*Considérations sur l'Art de la Guerre*, p. 29, 30.)

strength 4500 men. The tribunes, in concert with the centurions, divided the three classes of *hastati, principes, triarii*, into ten *ranks, manipules*, or *companies* each: the *velites* were distributed in equal portions among these thirty manipules: and the cavalry were divided into ten parts, called *turmæ* or troops. Such is the account given by Polybius, who, doubtless, describes the legion as it was constituted in his time.

The *hastati*, so called from the *hasta* or spear with which they were originally armed, commonly formed the first line in the order of battle; the *principes* were placed in the second line; whilst the oldest and best legionaries, classed under the name of *triarii*, constituted a reserve in the third line. The *triarii* were originally the only troops armed with the *pilum*, a species of heavy javelin, which will be described hereafter; and hence they are sometimes designated by the ancient historians under the name of *pilani*, while the *principes* and *hastati* are denominated *antepilani:* but these denominations necessarily ceased when the three lines adopted the same arms. The *velites*, distributed among the manipules, as already mentioned, were the light infantry of the legion, of which they formed about a fourth part; and known at first under the name of *rorarii* and *accensi*, they were afterwards called *velites*, and ultimately *ferentarii*. But the reader must be careful not to confound these light troops, which always formed part of the legion, with the cohorts of archers and slingers attached to the armies in the time of Cæsar; since the latter were merely auxiliary troops, and had nothing whatsoever in common with the legion. The legionary cavalry, composed of a body of 300 horse, denominated the *ala* or wing, and forming about the twentieth part of the legion, was divided into ten *turmæ*, of thirty horsemen each; while the *turma* was again subdivided into three *decuriæ*, of ten cavaliers each; and the whole was chosen from among the *equites* or knights, who formed one of the first orders at Rome.

When the classification had been completed, the tribunes of each legion proceeded to the appointment of centurions. They commenced by naming ten *first centurions* in each class, except that of the *velites;* after which they proceeded to the nomination of an equal number of *second centurions;* and the legionary infantry being divided into ten manipules of *hastati*, ten of *principes*, and ten of *triarii*, among which the *velites* were equally distributed, they assigned a first and a second centurion to each manipule; the first commanding the right, and the second the left of the manipule, under the orders of the first, whose place he supplied in the case of absence or death. The tribunes also named three decurions in each of the ten *turmæ* of horse; but the decurion first named had the sole command, and the two others were only his lieutenants. Thus a legion had sixty centurions or officers of infantry, thirty decurions or officers of cavalry, and six tribunes or officers of the staff. The tribunes commanded the legion each in his turn during two months; and this continued to be the practice until the epoch of the civil wars, when, for reasons sufficiently obvious, the command was intrusted to a *legatus* or lieutenant-general. The tribunes on service superintended the establishment and fortification of the camp, disposed the guards necessary for insuring its safety, transmitted to the centurions the orders of the general, took care that these were duly executed, and attended to the discipline and exercise of the troops; whilst the others were placed by the *legatus* or the consul at the head of detachments, reconnoissances, or foraging parties, and intrusted with the command of posts, or employed on particular missions, for raising contributions of money, provisions, clothing, and arms in the conquered countries; in a word, they were staff officers disposable for all kinds of service. The centurions were divided into several grades. Besides the distinction of first and second, established with reference to the manipule, they took precedence among themselves according to the relative distribution of the classes to which they belonged; so that a centurion of the *triarii* ranked above a centurion of the *principes*, and a centurion of the *principes* above a centurion of the *hastati*. And the first centurion of each class, that is, the *primi hastati centurio*, the *primus princeps*, and the *primipilus* or *primipili centurio*, commanded the whole of his class, or one of the lines of battle of the legion; which accounts for the high consideration that these three superior officers enjoyed among the Romans. They were commonly admitted to the council of the general, along with the tribunes; and the *primipilus*, the chief of all the centurions, by reason of the pre-eminence of his class, commanded the whole legion in the absence of the tribunes. Further, each centurion and decurion chose for himself, or received from the tribunes, a sub-officer to aid him in the details of the service; and we learn from Vegetius, that there was moreover placed at the head of each squad or tent of ten soldiers a *decanus* or corporal, who performed the duties of that humble rank.[1]

Such was the constitution of the legion in the time of Polybius, the friend and contemporary of the second Scipio. But an important, we might almost say a radical, change in its organization was afterwards introduced; a change which has been ascribed to Marius, and which appears to have commenced at the epoch of the wars against Jugurtha. The legions then ceased to be ranged in lines of *hastati, principes*, and *triarii;* for the last order of battle, according to the ancient formation, of which historians give any account, is that of Metellus against Jugurtha, as described by Sallust. From this period we always find the legions ranged by cohorts, without distinction of classes, in a double or a triple line. The classification which had been originally occasioned by difference of arms no longer served any purpose, after all the troops of the line were armed in the same manner; except to divide the legion into three large bodies of about 1600 each, including the *velites*, which formed part of them. But experience proving that such bodies were too numerous to be easily directed by a single commander, and too heavy and lumbering for the exigencies of Roman tactics, their place was supplied by a number of smaller and more manageable bodies, and the legion, consequently, divided into ten cohorts, each consisting of three manipules, under six officers, who preserved their denomination and command in their respective manipules. The force of the cohort was raised from 400 to 600 men, thus making the total strength of the legionary infantry 6000; and the first cohort was composed of picked men, who were intrusted with the eagle, under the orders of the *primipilus*. A new order of battle was also adopted, the legions being commonly drawn up in two lines of five cohorts each, leaving small intervals between each cohort. But Cæsar, justly considering these *lacunæ* dangerous, and thinking the new formation deficient in solidity, preferred a continuous alignement, and recurred to the ancient formation in three lines, placing four cohorts of each legion in the first, three in the second, and three in the third line.

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[1] Erant decani, decem militibus præpositi, qui nunc caput contubernii vocantur. (Vegetius, *De Re Militari*, l. ii. c. 8. See also Rogniat, *Considérations sur l'Art de la Guerre*, p. 7, et seqq. Paris, 1820.)

The civil troubles which led to the subversion of the republic produced still further changes. For a time the legionary cavalry entirely disappeared, and their place was supplied by auxiliary horse: strangers, and even slaves, were admitted into the legions, the force of which varied from 4000 to 6000 men: and the social troops disappeared by the admission of all the natives of Italy to the rank of citizens. In the imperial times, as we learn from Vegetius, the legion consisted of 6100 infantry and 726 cavalry. The decimal division of the infantry into cohorts remained the same. "The cavalry," says Gibbon, speaking of that attached to an imperial legion, "without which the force of the legion would have remained imperfect, was divided into ten troops or squadrons; the first, as the companion of the first cohort, consisted of 132 men, whilst each of the other nine amounted only to 66: the entire establishment formed a regiment, if we may use the modern expression, of 726 horse, naturally connected with its respective legion, but occasionally separated to act in the line, and to compose a part of the wings of an army."[1] This is at once clear and precise. But it has, nevertheless, been supposed, and not without reason, that when the legionary cavalry was augmented, the number of *turmæ* was proportionally increased; and that no such inequality as that mentioned by Gibbon existed between the *turma* attending the first cohort and those attached to the others. In fact the *turma* or squadron, at this period, consisted of 32, or, including the decurion, 33 men; and as the total number of cavalry belonging to the imperial legion was 726, it follows that there were in all twenty-two *turmæ*, of which four, or 132 men, were attached to the first cohort, and two, or 66 men, to each of the remaining nine. The result in both cases, however, is the same; while Gibbon's statement may perhaps be preferred as proceeding upon the more ancient division.[2]

The armour of the Roman infantry consisted of the demicylindrical buckler or shield, the cuirass or pectoral, the casque or helmet, and the ocrea or greave. The demicylindrical buckler or shield, four feet in length by two feet and a half in breadth, and constructed in the form of a tile, was composed of two or three pieces of timber fashioned and secured together in the manner of staves, covered with leather, strengthened at each extremity by a band of iron, and provided in the middle with an *umbo* or boss of metal, for the purpose of turning aside the missiles and pikes of the enemy. The casque, helmet, or head-piece of brass was variously formed, but generally fitted with projections at the base for protecting the neck and shoulders, and attached under the chin by *mentonnières*, covered with scales of brass. The cuirass or pectoral was a hollow plate of brass about a foot square, adapted to the form of the chest, and fastened with thongs of leather protected by metallic scales; but the centurions and foremost legionaries rendered themselves still more impenetrable to the steel of the enemy by using chain armour covered with brass scales. Lastly, the ocrea was a species of boot or greave, fortified with iron, and worn on the right leg, which the soldier advanced in striking his adversary.[3] Their offensive arms were the javelin, the *pilum* or heavy dart, the pike, and the sword. The sword called Spanish[4] was common to all the infantry of the legion. It had a short broad blade of excellent temper, which served either to cut or thrust,[5] and was worn by the soldier on the right thigh. The javelin belonged exclusively to the light infantry or *velites*. It was a species of dart, with a round shaft about three feet in length and an inch in diameter, shod at one extremity with iron about four inches in length, and tapering to a very sharp point. In the day of battle the light troops had each seven of these weapons, which they launched at the enemy with much dexterity and precision. When it became necessary to have recourse to the sword before the whole or any part of the javelins were thrown, the soldier passed them to his left hand, which remained free in consequence of the buckler being attached to the left arm. The light troops were also provided with bows and arrows, and slings, which they used in skirmishing at a distance. The *pilum* or heavy dart, intended to serve principally as a missile, was originally borne by the *triarii* alone, whence the name of *pilani*, but was afterwards appropriated to the *hastati* and the *principes*. Its shaft was of such a thickness as to be easily grasped by the hand;[6] and the weapon, including both wood and iron, was about seven feet in length. The iron, however, was of the same length as the wood, extending to the middle of the shaft, which was firmly inserted in it, and made fast by nails driven transversely; and it was of a square form, of an inch

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[1] *Decline and Fall of the Roman Empire*, vol. i. chap. iii. p. 13, 14, 8vo ed.

[2] "The turma of the Romans," says the Count von Bismark, "had, according to Vegetius, eight files and four ranks; *ten turmæ formed a legion*; the distances between the turmæ were equal to their front." (*Cavalry Tactics*, p. 273, Engl. transl.) It would be curious to learn in what edition of Vegetius the Count discovered that the *turma* of the Romans had eight files and four ranks, and that ten *turmæ* formed a *legion*, or brigade of *infantry* and *cavalry* united in very unequal proportions. Unless the Count has found out something to which the Romans themselves were strangers, he must have fancied that, in describing the formation of the infantry of the legion, Vegetius was speaking of the cavalry.

[3] When the Roman soldiers threw their *pila* or heavy darts, they had the left leg foremost; but when they engaged in close combat with the sword, they were taught to advance the right leg, which was accordingly protected by the iron-covered greave or boot above mentioned. (Vegetius, lib. ii. cap. 15 and 16; Justus Lipsius, lib. iii. dial. 2, *De Mil. Rom.*; Guischardt, tom. ii. p. 160.)

[4] The *gladius Hispaniensis* is thus described by Polybius:—Ἅμα δὲ τῷ θυρεῷ μαχαιραν, ταυτην δὲ περι τον δεξιον φερει μηρον. Καλουσι δὲ αυτην ΙΒΗΡΙΚΗΝ· εχει δὲ αυτη κεντημα διαφορον, και καταφορὰν εξ αμφοιν τοιν μερῶν βιαιον, δια το τον οβελισκον αυτης ισχυρον και μονιμον ειναι. The name of this weapon sufficiently indicates its origin. An unknown writer, quoted by Suidas, says that "the Celtiberians excelled all others in the manufacture of swords, strongly-pointed and double-edged; wherefore the Romans, laying aside the swords which had been in use among their ancestors, replaced them, in the time of Hannibal, with the Spanish blades. But (he adds) although they assumed the form, they were unable to imitate the temper of the steel and the beauty of the workmanship." Josephus says that, in his time, the Romans had two swords—one of considerable length, which hung at the left side, and another about a foot long, which they carried on the right thigh; in other words, a sword and a dirk, like the Scotish Highlanders. Similar changes in the arms of the soldiery may be remarked every century.

[5] The Romans invariably gave the point, and derided the practice of those who depended on the cut rather than on the thrust. "Præterea non *cæsim*," says Vegetius, "sed *punctim* ferire discebant. Nam cæsim pugnantes non solum facile vicere, sed etiam derisere Romani. Cæsa enim quovis impetu veniat, non frequenter interficit; cum et armis vitalia defendantur, et ossibus. At contra puncta, duas uncias adacta, mortalis est. Deinde dum cæsa infertur, brachium dextrum latusque nudatur. Puncta autem tecto corpore infertur, et adversarium sauciat ante quam videatur." (*De Re Militari*, l. i. c. 12.) This, we believe, is still accounted sound doctrine of fence.

[6] This seems to be the meaning of the Greek word παλαιστιαιος, applied by Polybius to the shaft or helve of the *pilum*; for, taking it in its ordinary acceptation, the shaft of the *pilum* would have been four inches in diameter; a size which, considering the length of the weapon, and the weight of its iron, would have rendered it an impracticable arm. Dionysius of Halicarnassus confirms this opinion by describing the *pila* as χειροπληθη or weapons that completely *fill the hand*. Polybius compares this formidable arm of offence to a boar-spear.

and a half at its greatest thickness, but its diameter gradually diminished to the point, which was exceedingly sharp, and near to which was placed a hook or barb, that served to retain the weapon wherever it penetrated. Besides this arm, which was necessarily heavy, the soldiers were sometimes provided with another of the same kind, but less massive both in the wood and the iron, which they held in the left hand, and discharged immediately after the former. The *pilum* was a weapon peculiar to the Romans. As soon as they came within a proper distance of the enemy, they began the combat by launching these heavy darts, with a force which, from their weight and the temper of the steel points, caused them frequently to penetrate both buckler and cuirass, so as to inflict the most hideous and desperate wounds. Having discharged these missiles, the legionaries instantly drew their swords and rushed upon the enemy with the utmost impetuosity, before he could recover from the effects of the volley of *pila*, by which his first ranks were generally overthrown.[1] The pike of the *triarii*, a weapon equally adapted for attack or defence, onset or resistance, was longer, less thick, and consequently more manageable, than the *pilum*, which was of little use except at the moment of commencing battle. Armed with this weapon, the veteran reserve of the legion often awaited *de pied ferme*, the shock of cavalry as well as infantry; and Livy assures us that they seldom or never quitted their pikes in battle. "The *triarii*," says he, speaking of a particular occasion, "disfigured the faces of the Latins with their pikes, the points of which had been blunted in the combat." These *troupes d'élite*, therefore, may be considered as the pikemen of the legion; although instances are to be found where they abandoned the pike and had recourse to the sword, which was always the weapon in which the Romans placed the greatest confidence, and with which, indeed, their most celebrated feats in arms were achieved. It may be proper to add, that, although this description principally applies to the legion as constituted in the time of Polybius, and although great changes were subsequently introduced, yet the arms, offensive as well as defensive, of the legionaries, remained nearly the same; with this exception, however, that all the troops of the line were at length armed in precisely the same manner, namely, with the Spanish sword and the *pilum*.

The horse had very nearly the same armour as the foot, and they were latterly provided with offensive arms similar to those used by the cavalry of the Greeks; namely, with a lance, having a shaft resembling two cones joined together at their bases, and pointed at both extremities, and a long, large sword, suspended by a shoulder-belt at the right side. There was a time, indeed, when they had only slender lances, pointed at one extremity, and wore no cuirass; but experience soon showed the necessity of adopting the Greek arms and equipments. The Roman cavalry was generally composed of a superior description of men, denominated knights, who on all occasions displayed the greatest valour; but they seldom mustered in force sufficient to produce great results, and their organization appears to have been in many respects defective.

It is evident, that a man placed on the back of a horse, without a saddle, or stirrups to serve as a fulcrum for reaction, can never exert half his proper force, nor combine it effectively with the momentum acquired from the velocity and weight of his horse. "Ces cavaliers," says Rogniat, "ne pouvaient être choisis que parmi les chevaliers, qui formaient un des premiers ordres à Rome. L'état leur fournissait ordinairement des chevaux; mais, peu habitués à l'équitation, ou persuadés qu'on est plus fort à pied qu'à cheval, ils mettaient souvent pied à terre, pour prendre une part plus décisive aux combats sérieux. Telle était (he adds) l'opinion des Romains, de la supériorité de l'infanterie sur la cavalerie, que, non content de n'avoir qu'un petit nombre de cavaliers, ils les transformaient encore en fantassins dans les occasions critiques."[2]

The Roman generals, even in the time of the consuls, do not seem to have followed any particular order of battle, but to have changed it according to circumstances, or the nature of the enemy they had to contend with. This is evinced by the various dispositions which were made at the battles of Tunis, of Cannæ, of Zama, and many others that might be mentioned. But still the chequer order or *quincunx* was that most frequently employed in the earlier times of the republic; owing, doubtless, to the facility it afforded of forming line or column at pleasure. Leaving the *velites* or light troops out of view, as constituting no part of the main battle, the reader will observe that the manipules of the first line, or the *hastati*, were formed upon a front varying according to the depth, which was generally ten, but not unfrequently six; and that the interval between each manipule was exactly equal to its front. Thus, supposing the legion 5000 strong, a manipule of 140 men would be ranged ten deep upon a front of fourteen; and as each soldier occupied three feet,[3] the extent of front presented by a manipule would accordingly be fourteen yards. Since the first line, therefore, consisted of ten manipules, it contained of course nine intervals of fourteen yards each; exactly opposite to which, but at a considerable distance in the rear, were stationed nine of the ten manipules of the second line, or *principes*, drawn up in the same manner as those of the first, upon fronts of equal extent; the tenth manipule of the latter outflanking by the whole length of its front the right or the left wing, as it might be, of the first line. The *triarii*, of less depth than the *hastati* and *principes*, but for the most part in continuous formation, occupied the third line. Now, it must be obvious at the first glance, that this order of battle presented several important advantages. By advancing the manipules of the *principes* through the above-mentioned intervals, until they dressed with those of the *hastati*, line was at once formed: again, by moving them fourteen yards either to the right or left, the depth of the formation was doubled; while, by placing the manipules of the *triarii* exactly behind those of the *principes*, as was done when the legions were menaced by elephants, the whole was formed into columns, separated into intervals equal to their respective fronts, through which these animals, pursued and goaded by the *velites*, might be driven to the rear, without doing

[1] For a particular description of the use of the *pilum* in commencing the attack, see Cæsar's *Commentaries de Bello Civili*, lib. iii. cap. 92. The weight of this arm "ne permettoit pas de le darder de loin," as Guischardt says. It was the business of the *velites* to harass the enemy with their javelins and other missiles before the action became general. As the hostile lines approached, the light troops retired through the intervals or by the flanks, where they generally took their station; and when the former were within a short distance of each other, the *hastati* and *principes* darted their *pila*, and then rushed on, sword in hand, to close combat. Hence the proverb employed by Vegetius to describe the proximity of two armies: *Ad pila et spathas ventum est.*

[2] *Considérations sur l'Art de la Guerre*, p. 10, 11. Paris, 1820.

[3] The ranks of the manipule being also drawn up at the distance of three feet from one another, the whole space occupied by the Roman soldier was consequently nine square feet of ground; and this open order was seldom departed from, even in the charge. It is to be observed, however, that the second rank of the manipule was so disposed as to cover the intervals of the first, the third to cover those of the second, the fourth to cover those of the third, and so on to the last; in other words, the arrangement of each manipule individually was a precise type of their collective disposition in order of battle.

any mischief. Lastly, if it was desired to form the legion in three continuous lines, this was instantly effected by simply closing up the intervals between the manipules of the first and second lines; the *triarii* or reserve being, as we have already said, drawn up in a continuous formation, except when it became necessary to open a passage for elephants. And all these various evolutions were performed with a rapidity and precision which have seldom been equalled and never surpassed by the troops of any other nation.

At a later period, however, the Roman tacticians employed a different order of battle, distinguished for its greater compactness and solidity, as well as for the facility and rapidity with which it might be formed from the order of march, even in presence of the enemy. According to this method each manipule of the legion formed only a single rank in its order of battle; consequently the two classes of *hastati* and *principes*, ranged each upon its first manipule as a front, formed two lines ten deep. But as each man occupied three feet every way, and as the lines were separated by an interval equal to half the extent of their front, it is obvious that each line occupied a front of 120 yards, by from ten to twelve yards in depth; and that they were separated from each other by an interval of about 60 yards. Again, at an equal distance in rear of the *principes*, the *triarii* formed the reserve of the legion in the third line; and the whole, ranged in this manner in three lines, constituted a square order, as deep as it was broad; while the *turmæ* of the cavalry covered the flanks of the lines, and the eagle or standard of the legion was intrusted to the keeping of the *primipilus* on the right of the line of the *triarii*. This order, usually denominated *legio quadrata*, was that adopted by all skilful generals when in presence of an enemy. But the different legions composing an army were ranged upon the same principle, with reference to one another, as the different ranks of the same legion; in other words, they were formed *en echelon;* each legionary line thus making one of the sections of the column, and the baggage occupying the intervals, while the *velites* covered the flanks. In this order of march, if the enemy threatened an attack on the front, each legion in succession formed line with that at the head of the column; the second almost in an instant, the third somewhat later, and the fourth, or the most remote, in about seven minutes, which were accounted sufficient for developing the order of battle on the front. But the order of battle on the flank was of still more rapid formation. For, the baggage withdrawing from between the sections, and assembling on the side opposite to the enemy, each legion executed what is technically called a *quart de conversion* on its *hastati*, and the whole army immediately found itself in order of battle; two minutes being sufficient for the performance of this simple evolution. It seems evident, then, that the celebrated *quadratum agmen* of the Romans, which has hitherto been so often treated of, and so little understood, consisted of a certain number of *legiones quadratæ* disposed *en echelon*, or at least in column, as we have just described: and, from the advantages of this order of march, particularly its rapid convertibility into an order of battle either on the front or the flank, it is easy to understand the reason why the Roman historians have censured so severely the generals who neglected to adopt it in presence of the enemy. So much, then, for Roman tactics, as connected with the elementary formation of those brigades or divisions which constituted the units of Roman armies.

The distinguishing characteristic of the legion consisted in its astonishing mobility, united with its power of preserving its order of battle undisturbed, and of constantly rallying when forced to give way. It possessed a sort of flexibility which enabled it to adapt itself to every change and variety of circumstances; and no other military body, perhaps, ever executed so numerous evolutions in the presence of an enemy. Its attack was impetuous and formidable; but if that failed, it then displayed its most characteristic excellence, by fighting in retreat. In this way it vanquished the phalanx, although it was unable to withstand the direct shock of that dense body in the open field. At the battle where Flaminius defeated Philip in Thessaly, the Macedonian phalanx gained considerable ground on the legions; but the Romans, although forced to give way, preserved their order,—returned repeatedly to the charge,—and, even while in the act of retiring, extended their line so as to gain the flank of the Greeks. Philip durst neither accelerate his march, nor send out any detachment in pursuit; so that twenty manipules had time to turn his flank and fall upon his rear, which speedily decided the fate of the battle. As the phalanx acted with long pikes, and in close order, the least derangement caused by the ardour of the soldier in pursuit, or by inequality of ground in its march, necessarily exposed it to the legion; which, dividing itself into a number of separate corps with the same facility that it formed one corps and one line, possessed the power of attacking it on two or more sides at the same time. "La légion doit donc," says Guischardt, "être envisagée sous deux faces. Comme infanterie en bataille contre une autre infanterie, elle eut son ordonnance particulière à rangs et files ouverts, conformément à ses armes; et alors elle n'eut rien de commun avec la phalange. Lorsqu'elle a eu de la cavalerie en tête, elle cessa d'avoir son ordonnance particulière."[1] This wise distinction rendered the legion formidable alike to every nation on which Rome chose to make war;[2] but neither as infantry against infantry, nor as infantry prepared to resist cavalry, which duty was principally performed by the *triarii*, until all distinction of classes and arms merged in a homogeneous formation, had it any thing in common with the phalanx; for its victories, no less than its reverses, had demonstrated the inutility of deep formations, and showed that its real power depended on its distributive rather than its concentrative energies,—on its mobility and flexibility rather than on its weight or impulsion. Hence, on the day of Pharsalia, it was remarked, as an extraordinary circumstance, that Pompey had formed his legions ten deep; a novelty which, as every schoolboy knows, served no other purpose, on that occasion, except to add to the carnage.

In following the Romans in their wars under the emperors, we find their discipline and their tactics declining from age to age, in the same manner as they had advanced and improved. The spirit of change, though productive of some ameliorations, proved ultimately fatal to the legion. As long as the Romans continued faithful to the precepts and rules of the ancient masters, their infantry maintained its superiority: in proportion as these were departed from it declined; until at length, having lost all its distinctive qualities, it was constantly beaten and overthrown by the numerous cavalry of the barbarians. To ascribe the gradual declension and ultimate fall of this infantry to luxury, refinement, love of ease, corruption of

[1] *Mémoires Militaires*, tom. i. p. 84.

[2] The cavalry of the Parthians, though peculiarly formidable, durst not attack the legions commanded by Marc Antony, and confined itself to harassing them from a distance with its arrows. At the battle of Nicopolis, a single legion of the army of Domitius defeated and put to flight the whole cavalry of king Pharnaces; and, with a handful of infantry and some horse, Pompey defied the numerous cavalry of king Oroses.

manners, or other analogous causes, is merely to indite silly common-places, displaying the most profound ignorance of history and of human nature. Its catastrophe was occasioned by the decay of discipline alone. For experience shows that hardy and effective soldiers may be formed in the most polished as well as in the rudest and most uncivilized periods of society; and that nothing more is necessary to produce this result than an uncompromising system of discipline. Accordingly, under Vespasian, and Titus, and Trajan, and Hadrian, and Aurelian, and other warlike emperors, who enforced the precepts of the ancient masters, and restored the ancient discipline, the Roman infantry regained its reputation, and proved itself as formidable as it had ever been in the best times of the republic. The corruption was not in the soldiers, but in the men by whom they were organized; in those whom the experience of so many ages, and the conquest of the world, had failed to impress with a due conviction of the value of that system of discipline by which such prodigies had been performed. "On ne peut voir sans indignation," says Guischardt, "la mauvaise ordonnance que les Romains au tems de Végece avoient substituée aux anciens modèles. Ils étoient rangés sur six de hauteur, et même quelquefois sur trois. Chaque rang avoit des armes différentes, dont la plupart étoient des armes de jet, comme des arcs et des frondes. D'un rang à l'autre il y'avait six pieds d'intervalle, et dans les files on avoit retranché les trois pied de distance, parcequ'on ne se battoit plus avec l'epée: on avoit même oublié le véritable usage du *pilum*. Le troisième et le quatrième rangs dévoient de tems en tems se détacher, et charger à la tête de la ligne, et revenir ensuite à leur poste. On ne sauroit rien imaginer de plus pitoyable. Ces deux chapitres de Végece marquent bien clairement l'ignorance de l'auteur, et la décadence de la bonne discipline chez les Romains."[1] From innovations like these, and others still more absurd which succeeded them, what results could be anticipated except those which history has recorded; namely, disgraceful defeats, calamitous reverses and, at length, the final overthrow of the Roman power itself? The legions, degenerated into a feeble militia, sold the empire which they were incapable of defending; and having neither the courage which sometimes supplies the place of discipline, nor the discipline which supplies that of mere courage, they fell an easy prey to the swarms of Goths, Huns, and Vandals, by whom it was successively overrun, and at last completely destroyed.

Army of the middle ages.

The fall of the Western Empire, like that of a colossal structure, was succeeded by a thick cloud, which overspread Europe, covering it with darkness and desolation. All that remained of science or of art perished in its ruins, and the only relic of the catastrophe was the shadow of a mighty name. But the barbarians who had subverted the Roman power appear to have brought with them, from their forests and wildernesses, the elements of a system which was destined to thicken the darkness in which it originated; to bind Europe for ages in the fetters of the most abject thraldom; nay, even to maintain a long and fierce struggle against the reviving energies of the human mind, and the regenerative powers of society. Its foundations were laid in their peculiar character and habits, as affected by their position and their wants; and, as they had fought neither from the love of glory, to which they were insensible, nor from a thirst of vengeance, which nothing had contributed to stimulate, the only fruits they dreamt of reaping from victory were the spoils of the vanquished. The countries which all had conquered were considered the property of all, and each claimed a share proportionate to his services and the number of his retainers. Subsisting rights or possessions weighed as nothing in the estimation of these wild hordes, who sought for establishments in genial climates and fertile regions. They demanded a territorial division and apportionment, which was accordingly made upon some rude principle of equalization. But, as these lands were the reward of military service, so they were to be held by that tenure alone. The common interest and the common defence required that this condition should be annexed to the allotment, or, as it was afterwards called, the *feu*. Each great vassal of the liege lord was bound to have in constant readiness to take the field, a certain number of men, clothed, armed, and equipped at his own expense. Hence arose the *feudal system*, which, founded on military rather than civil principles, was an aggregation of petty sovereigns and petty principalities, under a nominal head, to whom all swore fealty, but few or none owned obedience; a military aristocracy, in short, under the mask of a monarchy. But this system, however well calculated to keep alive a spirit of ferocity, seemed to oppose a formidable barrier to the revival of the military art. Its maxims, necessarily hostile to the establishment of a standing army, by which the great barons might have been coerced, limited the force of the state to the contingents of feudal militia, which the crown vassals could bring into the field; a tumultuary mass, without coherence, which the first victory or the first reverse generally dispersed. During this period, accordingly, the wars of Europe were desultory and indecisive. An incursion constituted a campaign, and a foray an expedition. Armies were everywhere without order and without science; battles were gained by accident or by valour, never by discipline; while conquests, rapid as torrents, were generally as destructive and as transitory. The love of military glory was extinguished; petty wars, occasioned by baronial feuds, raged fiercely, preying upon the vitals of society; and the fruits of organized barbarism were general misery and desolation. The people were abject serfs, the barons ferocious brutes, the sovereign an absolute cipher. Anarchy, tyranny, ignorance, and spiritual thraldom, formed the characteristics of the first ages of feudalism.

The crusades.

At length, in the eleventh century, arose a monk, called Peter the Hermit, who preached with all the fervour, and more than all the success, of any known apostle, the duty of recovering the Holy Sepulchre from the infidels; and as the church lent her powerful aid to second the efforts of Peter's enthusiasm, the contagion soon spread throughout every part of Europe, and thousands of all countries rushed forward to enlist under the banner of the cross. The history of mankind affords no parallel to the madness that was thus produced, either as regards its universality or its duration. It affected all Christendom in nearly an equal degree; and, during two centuries, army after army marched for Palestine, to melt away under the sultry sun of Syria, or to be mowed down by the swords of the Saracens. But it agitated the minds of men by a new and powerful impulse; and although its essence consisted in the wildest fanaticism which had ever taken possession of the species, yet that inexplicable frenzy, combining with a spirit of enterprise and adventure, gave birth to institutions which were destined to exert a powerful influence upon the whole frame of society, and which have left a marked impression even on the manners, customs, and feelings of modern times. Viewed in a military light, the armies of the crusaders were mere

[1] *Mémoires Militaires*, prel. disc. xxiv.

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tumultuary masses, impelled by fanaticism to deeds of heroic valour, but as destitute of order and discipline as their leaders and chiefs were ignorant of military science; nor had all the reverses they sustained the effect of inculcating the simplest principles of the art of war, or teaching the necessity of adopting some kind of organization. Every thing was trusted to numbers without combination, and to individual bravery exerted as chance or impulse happened to direct. And so deeply engrained in men's minds was the spirit of feudalism, and so incompatible did that spirit show itself with the slightest advancement in the military art, that the mailed chivalry of the ages immediately succeeding the crusades, although offering the finest elements that ever existed for the organization of an invincible force, appears at no time to have had any principle of effective combination, or to have been capable of acting with unity and concert in any grand operation. Yet the principal strength of armies in the middle ages consisted in their cavalry; which, composed of men of superior grade, and formidable from its bravery no less than from the armour of proof in which it was encased, easily proved itself superior to infantry without formation, and with no other discipline than that which instinct dictates even to the most barbarous tribes.

Invention of gunpowder.

But a new epoch approached. Gunpowder was invented, or at least improved, by Berthold Schwartz, a Franciscan monk of Cologne, and was first employed in warlike operations in the early part of the fourteenth century. This discovery, as Guibert justly remarks, did not lead to any *immediate* improvement in the art of war: indeed a century and a half was necessary in order to make the use of fire-arms general; but it is nevertheless to be considered as the real cause of the complete reform which was at last effected in the constitution of armies, as well as in their discipline and tactics. Since the first employment of gunpowder, there have been *seven principal periods* in the history of the military art.

First period.

The first begins with the employment of cannon, and extends to Charles VIII.'s campaign in Italy; or from the early part of the fourteenth until towards the end of the fifteenth century. This period, during which the art of war began to revive from the state of barbarism into which it had sunk since the downfall of the Roman empire, includes the wars of the Spaniards against the Moors, of the English against the French, and finally, of the Italian republics against each other. The cavalry, composed of the nobility and gentry, still constituted the flower of armies, and formed the chief support of princes and their kingdoms. At the storming of fortresses, or when important posts were to be occupied and defended, and a bold, determined soldiery was required, the knights dismounted and fought on foot. They were the dragoons of that age. Each knight was attended by his esquire; and, besides these there were also archers, generally the vassals of the knights, who, being more lightly armed, and riding smaller horses, served as a kind of light horsemen. At the beginning of the fourteenth century, indeed, the distinction of heavy and light horse was common in European armies. The former, consisting of tenants *in capite*, holding of the crown by tenure of military service, or their substitutes (*servientes*), were denominated *men-at-arms*, from their being armed *cap-à-pied*; the latter, composed of yeomen, were named *hobilers*. The knights rode what were denominated war-horses, which, like their riders, were covered either with chain or plate armour, or with both; and these men of iron carried a long and powerful lance armed with an iron head, a long sword, a short sword, a dagger, and a mace or battle-axe.[1] Their formation for combat was exceedingly simple. They fought man to man; each armed knight singling out his opponent, and riding against him with his couched lance, in order to throw him out of his saddle, or to make him prisoner. The esquires, or armour-bearers, followed as a second rank, or at least acted as seconds to the knights, whom they assisted in battle, bringing them fresh arms and horses when required, and seeking opportunities of distinguishing themselves in order to obtain the honour of knighthood. Nothing, however, was known of scientific movements, until Charles the Bold compiled an exercise book in 1473, instructing cavalry how to attack in close and extended order, or to link the horses and fight on foot. An engagement was generally commenced by single knights riding forward and challenging opponents from the hostile army; and the result of these single combats sometimes determined the fate of the day.[2]

Second period.

The second period, from the campaign of Charles VIII. in Italy to the beginning of the wars in the Netherlands, or from the end of the fifteenth to the middle of the sixteenth centuries, comprises the wars of the French, Spaniards, and Germans, in Italy. During this period chivalry gradually declined, and war began to assume a new aspect. At the close of the contest with England in 1445, Charles VII. of France established the first standing army, consisting of 16,000 infantry and 9000 cavalry, divided into fifteen *campagnies d'ordonnance*;[3] he appropriated funds for the payment of these troops, and appointed officers to discipline and command them; and, although apprehensive at first as to the success of the experiment, he at length succeeded in organizing a force, which enabled his successor to repress the turbulent spirit of the feudal aristocracy, to strengthen the power of the crown, and to carry on foreign operations with a consistency and vigour hitherto unknown. The Italian campaign of Charles VIII. proved the superiority of a standing army over an assemblage of feudal militia, and consequently established its reputation. With a force of about 20,000 men, he overran the whole of Italy; and, had his ambition been equal to his success, or rather had he known how to reap the fruits of victory, he might have rendered himself permanent master of that country. Other nations imitated the example of France: a change took place in the military system of Europe: the practice of calling out knights ceased of itself: and mercenary, or at least paid troops, regularly disciplined and organized, became the only force that was trusted or employed. The characteristic of this period was deep formation, both in the cavalry and the infantry.

Third period.

The third period comprehends the great war of independence, carried on by the Netherlanders, in order to emancipate themselves from the yoke of Spain; and it extends from 1568 to the general suspension of hostilities in 1609. Here fought, on one side, art, and an army formed by the experience of more than half a century of war, under Charles V. and his son Philip II.; on the other, the inhabitants of the Low Countries, living only by trade and the arts of peace. A people, consisting chiefly of manufacturers and merchants, inhabiting a country of small extent, and already much exhausted by a long-continued exercise of tyranny and oppression, scrupled not

[1] Meyrick's *Critical Inquiry into Ancient Armour*, vol. i. p. 174. Chain-armour first became covered with plates at the beginning of the fourteenth century; but entire plate-armour did not make its appearance until about a century after.

[2] The only military productions of this period were the regulations of Charles the Bold, above-mentioned, with those of Louis VII. of France, and of John Ziska, general of the Hussites.

[3] See Père Daniel, vol. i. p. 155.

to draw the sword, in defence of their liberties, against the richest monarch of the age, the sovereign of Spain and the Indies, and master of the most numerous as well as the best-disciplined forces, commanded by generals distinguished above their contemporaries by their skill in the art of war.[1] A more unequal contest cannot well be imagined; and never was the issue of any dispute more contrary to what the parties had reason to anticipate. But the struggle was protracted; and in proportion as the Netherlanders were formed to war, the bravery and discipline of the Spaniards relaxed. Under the skilful tuition and able conduct of Nassau, the foe which had at first appeared so contemptible to the haughty Spaniards, tore the laurels from their brows, and at length drove them, defeated and disgraced, from the country which had suffered so long under their grinding oppression and their insolent misrule. This war was followed by great changes, both in the organization and tactics of armies. The cavalry was divided into cuirassiers and light horse; the use of the lance was discontinued,[2] and its place supplied by the sword and pistol for the heavy, and the carbine for the light horse; and these were now trained to execute a variety of movements and manœuvres at full speed. The infantry was also placed upon a better footing, both in respect to discipline and formation; although the prejudice in favour of columns or masses seems still to have continued, notwithstanding frequent experience of their inutility, as well as of the destruction to which they were exposed from the concentric fire of artillery.

Fourth period.

The fourth period comprises the Thirty Years War, the pretext for which, according to Bulow, was the happiness of heaven, but the motive the goods of the earth: it extends from 1618 to 1648. The peace which had terminated the struggle for independence in the Low Countries, after a protracted contest of above half a century in duration, lasted only nine years; when a new war broke out, which can only be considered a continuation of the former. The hero of this war was Gustavus Adolphus; and he, like Prince Maurice of Nassau,[3] was the creator of new tactics. This warlike monarch departed from the dense formation of his predecessors, and drew up his infantry six deep; which was considered an innovation that nothing but his success could justify. His opponents, Tilly and Wallenstein, formed their infantry in solid masses thirty deep; which, nevertheless, proved unable to contend with the linear formation of the Swedish troops. Until about the middle of this war, it still continued the practice to form cavalry in from four to eight ranks. But Gustavus also departed from this rule, and formed it in three ranks; although it appears from Harte, that, at the battle of Leipsic, it was drawn up four deep, probably on account of the dense formation of the imperial cavalry, which was formed in eight ranks. In the intervals he stationed platoons of infantry, fifty and upwards strong, as well as light guns; doubtless from a conviction that cavalry, unless supported, were unable to contend with infantry. His great object appears to have been, to give greater mobility to the two principal arms of a military force, and thus to gain in celerity of movement what he had lost in weight or impulsion. He knew that the momentum would remain the same, if the motion was increased proportionally to the diminution in weight.

Fifth period.

The fifth period comprehends the wars of the French in Italy, in Germany, and in the Netherlands, as well as the northern and Turkish wars, and embraces a period of ninety years; namely, from 1648 to 1738. The peace of Westphalia put a period to nearly a century of war. The results of this conflict were the secularization of ecclesiastical property, the complete establishment of the Protestant religion, the recognition of mental freedom, the decay of the Papal power throughout Europe, and the triumph of national independence. But during the long-continued struggle in Germany, two hereditary enemies appeared,—the Turks and the French, The former were expelled in a single campaign, and never again attempted any serious invasion. The latter entered upon a series of wars of which we have not yet probably seen the termination. The ambition of Louis XIV., however, and the wars to which it gave rise, rapidly developed the art of carrying on military operations, and formed generals whose names adorn military history. Opposed to a French Turenne, Luxembourg, and Condé, stand Montecuculi, Marlborough, and Eugene of Savoy; Louis of Baden may rank with Catinat or Vendôme; and many other generals of eminence illustrate this period, which was less remarkable for changes in the constitution and organization of armies than for the talents displayed in conducting their operations in the field. It was the era of great commanders. In the north the Swedes, Poles, Brandenburgians, and Muscovites, fought alternately on the plains of Poland and the steppes of the Ukraine. Under Charles XII. the Swedish infantry attained a high degree of perfection, and proved uniformly successful until it was so rashly committed at Pultowa; while the cavalry, without defensive armour, which the chivalrous monarch rejected, consisted almost entirely of dragoons.[4] The principal improvements of this period, however, are chiefly due to the French, who made rapid advances in all the branches of military science.

Sixth period.

The sixth period includes the three Silesian wars; namely, from the beginning of the first Silesian war in 1740, to the breaking out of the French revolutionary war in 1792. For a century previous to this, Prussia appears to have been chiefly employed in preparing herself for the brilliant part which she acted under Frederick II. To the celebrated elector, Frederick William, the Prussian military power in a great measure owed its origin. This prince grew up, as it were, in a camp, and even in his boyish days, was present at the sieges of Breda and the Schenkenschantze. Arrived at the government, he endeavoured to infuse a new spirit into the army; and so well did he succeed, that, in 1672, he was enabled to promise the republic of Holland an auxiliary force of 20,000 men. At the period of his death the elector left behind him a well-organized army of 30,000. When Frederick the Great (or, as he

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[1] Watson's *History of Philip II.* vol. i. p. 428.

[2] "La lance," says Montecuculi, "est la reine des armes pour la cavalerie." (*Mémoires*, liv. i. c. 2.) And this opinion seems to be gaining ground at the present day; for experience has shown, that cavalry can never make any serious impression by means of fire-arms, while, with swords alone, they are wholly unfit to contend with infantry.

[3] Bismark's *Cavalry Tactics*, p. 307; Guibert, *Essai Général de Tactique*, p. 68.

[4] Charles XII., not content with making the cavalry, without any connection with or dependence upon other arms, but from confidence in itself, charge the enemy's horse at full speed, without firing, led it equally against intrenchments and batteries, and always with success. "He knew," says Count Bismark, "that by the rapidity of motion, the natural vivacity of the majority of mankind is increased, and, often mounting to a blind fury and foolhardy enthusiasm, leaves no time for consideration or calculation of danger; that at such a moment death loses its terrors, and *Victory!*—but with living colours—presents itself to the soul of the wildly-rushing warrior." (*Cavalry Tactics*, p. 319, 320, 321.) At the same time Charles appears to have had a love of fighting for its own sake; and it was probably this peculiarity of temperament, as much as any calculation of results, which gave to his movements that impetuosity, which neither natural nor artificial obstacles could check or resist.

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is called by the Germans, *der Einzige*, the Unequalled) ascended the throne, he found the army about 80,000 strong, and drilled to a precision of movement, as well as a rapidity in firing, until then unknown. This was owing to the exertions of Prince Leopold of Dessau, who may be considered the founder of the modern system of tactics, having invented the iron ramrod and the equal step,—reduced the formation of the infantry from four to three ranks, thereby increasing the effect of musket fire,—and, in short, laid the foundation of the system which Frederick afterwards improved, by giving to infantry-movements greater lightness and facility. With an army thus prepared for action, Frederick took the field in 1740. But the first two wars passed quickly by; and the intervals of peace were employed in reforming whatever experience had shown to be defective in his system,—in practising a vast variety of deployments,—and, above all, in introducing that celerity of movement which had become so essential in modern armies, with reference both to their numbers and the extent of their front. When the third Silesian or Seven Years War broke out, Frederick, forsaken by his allies, and menaced on all sides by powerful enemies, seemed on the very verge of destruction. But if he stood alone, he stood unmoved, like the oak, braving the storm, and conscious of the power to weather it. Nor was he without some peculiar and decided advantages. On the one hand, his natural *coup d'œil*, which was perfect; the unity and power of his will; the habit of his troops to remain firm in all situations, and to execute every movement with precision, even in the very tumult of battle; the never-shaken confidence in their leader, and the enthusiasm with which he was regarded by them: and, on the other, the division, weakness, and want of system or connection in the enemy's plans of operation; their partial and lukewarm mode of execution; together with the inferiority of their troops in organization, and of their commanders in genius:—these were the causes which enabled Frederick to retire from this bloody seven years conflict with a prodigious increase of fame, and without the loss of an acre of territory.[1] "Depuis la guerre de la Succession," says Guibert, "on n'avoit pas vu tant d'armées en campagne et réunies contre un seul prince. Sa science et leurs fautes furent le contrepoids de tant de forces. Jamais guerre ne fut plus instructive, et plus féconde en événemens. Il s'y fit des actions dignes des plus grands capitaines, et des fautes dont les Marsin auroient rougi. On y vit quelquefois le génie aux prises avec le génie, mais plus souvent avec l'ignorance. Partout où le roi de Prusse put manœuvrer il eut des succès. Presque partout où il fut réduit à se battre, il fut battu: événemens qui prouvent combien ses troupes étoient supérieures en tactique, si elles ne l'étoient pas en valeur."[2] Such was the character of the Prussian army of this period, and such the military genius of the great monarch by whom it was commanded. Mere tactical details are foreign to the object of this article, and therefore we abstain from entering into them, excepting in as far as they may seem necessary to throw light upon the constitution and composition of armies. That of Prussia was long considered a model for imitation. Under Generals Siedlitz and Ziethen its cavalry attained a degree of perfection unequalled either before or since. "There was but one Seidlitz," says Count von Bismark. In playing the mighty game of war, its infantry was also superior to any other of that age; and if subsequent events somewhat tarnished its reputation, it has never ceased to be one of the best organized and most completely equipped bodies of foot in Europe. The Austrians, as their wont is, only improved on compulsion, and when fairly beaten out of their old system of masses and deep formations.

Seventh period.

The armies and the science of this period, however, were destined to be far outnumbered and surpassed in the seventh and last, which embraces the military systems and establishments of our own times. These, accordingly, we shall now proceed to describe in detail; confining our accounts principally, if not exclusively, to their actual rather than to their former condition and strength; and commencing with the army of France, which has not only played a most conspicuous part since the commencement of the revolutionary wars, but has latterly served as a sort of model on which the other armies of Europe have been more or less formed.

French army.

From time immemorial, the Gauls were inhabited by a race of men distinguished for their bravery. Hardy and enterprising under the two Brenni, obstinate and persevering in their attacks against Cæsar, we find them cutting a conspicuous figure as auxiliaries in all the wars of ancient Rome. They passed through the middle ages with equal distinction; and if they were forced to yield to the irruption of the Franks, the amalgamation of the two nations had only the effect of adding to their energy. The wars of Charlemagne and the crusades; the successive invasions of Italy by Louis XII., Charles VIII., and Francis I.; and, lastly, the struggles maintained against all Europe by Louis XIV., showed what might be expected from French armies when properly commanded. But the fatal results of the Seven Years War, the wretched intrigues of the court of Louis XV., and still more the spirit of infatuation which appears to have become endemic after the disgraceful Hanoverian expeditions, eclipsed, in an instant, ages of glory, and rendered the army of France an object of ridicule to Europe. After the peace of 1762, some measures were taken with the view, as was pretended, of remedying the supposed defects in the constitution of the army, and restoring its character. But the French ministry of that day, ignorant of the real circumstances which had led to its successive defeats, and incapable of comprehending the dispositions and strategical movements by which success in war is attained, contented themselves with searching into the most minute details of discipline and instruction for the causes of failures which were solely attributable to a bad choice of generals, and a faulty direction of great operations. They imagined that the armies of Frederick had triumphed in consequence of oblique marches, the particular cut of their uniforms, and a thousand other absurdities which it would be impossible to credit, were not the amusing discussions of that period embodied in public documents of unquestionable authenticity; they disputed about ployments and deployments *en tiroirs*, about *tranches* and *plesions*, about a Prussian order and a French order; they formed camps in order to judge of the advantages of these different systems; and they fancied that they had discovered the sublime of the art in the mechanism of the instruction of platoons.[3]

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[1] Bismark's *Cavalry Tactics*, p. 323.

[2] Guibert, *Essai Général de Tactique*, tome i. p. 77, 78.

[3] "On étoit si fort engoué de tout ce qui ressemblait à la tactique Allemande," says Jomini, "qu'il suffit á cette époque de porter un nom Tudesque pour faire une fortune militaire. Un certain capitaine Pirch, sorti des rangs de l'armée Prussienne, passa pour un émule de Frédéric, sur la simple présentation d'un mémoire dans lequel il donnait des idées pour aligner des bataillons sur les drapeaux; on se crut heureux qu'il daignât accepter un régiment et l'instruire suivant sa méthode." (*Histoire Critique et Militaire des Guerres de la Révolution*, tom. i. p. 214.) Under the government which promoted Pirch, and indeed under that which succeeded it, Kléber, Moreau, and even Napoleon himself, would have been condemned to an eternal nullity.

"Encore un pas retrograde," says Jomini, "et les troupes Françaises se fussent trouvées au niveau des soldats du pape."[1] But the American war gave a check to these mischievous fooleries, and revived the spirit of emulation, which is the source of the most brilliant feats in war; while the expeditions to Grenada and St Eustatius, together with the campaigns of Lafayette, Saint-Simon, and Rochambeau, in a great measure restored the reputation of the French arms, and prepared the way for still more important achievements. The staff, the government, and the *faiseurs* were still divided between different systems. But while the chiefs were perplexing themselves with theories, the troops improved both in discipline and manœuvres; and had it not been for the repeated shocks which their organization experienced in consequence of frequent changes of ministry, and the introduction of certain radical innovations, which completely broke up the old battalions in order to amalgamate them with new levies, Louis XVI. would have possessed an army capable of defending the monarchy, and might have been able to restrain and resist that revolutionary frenzy to which he was destined soon to become a victim. In consequence of the disorganization thus introduced, the regiments of the line were in a wretched condition at the breaking out of the war in 1792. But a single measure saved them from destruction. The nomination officers taken from the *tiers-état* filled the ranks with an ambitious and warlike youth, burning to distinguish itself; while emulation, the chances of preferment, and the love of country, supplied for a time the want of discipline, and formed powerful motives for stimulating improvement.

At the end of the year 1791, the French infantry consisted of 105 regiments of two battalions each, 14 battalions of light troops, and 170 battalions of national volunteers; or 394 battalions in all. By the decree of the 5th May 1792, the number of the volunteer battalions was raised to 200, and the strength of each was increased from 226 to 800 men. The cavalry was composed of two regiments of carabineers, consisting of four squadrons each; 24 regiments of heavy cavalry of three squadrons each; 18 regiments of dragoons of three squadrons each; 12 regiments of chasseurs of four squadrons each; and 6 regiments of hussars of three squadrons each; in all 206 squadrons. So that the total strength of the French army at this period did not exceed 160,000 infantry, 35,000 cavalry, and 10,000 artillery; while 20,000 men were still wanting to bring the different regiments to their full complements. But this deficit was soon supplied by the multitude of volunteers who flocked to the national standards when the duke of Brunswick invaded France at the head of the Prussian army.[2] The revolution, however, had not yet developed its energies; nor had the world as yet any suspicion of the prodigies which the system of terror, afterwards organized, was destined to achieve. In 1795, France presented the formidable aspect of a vast camp. The decrees of the 23d August and the 5th September 1794 had hurried the whole youth to the frontiers. Nearly 1,200,000 men were in the pay of the republic; and, after deducting those employed in accessory services, and in the navy, the number of combatants in the field cannot have amounted to less than about 700,000. The official state of the force of the French armies, as at the 5th April 1794, presents an aggregate of 794,334 men, including garrisons, but exclusive of the army of the interior, whose head-quarters were at Paris; which, allowing one fifth for those in the depôts and for the sick, would give an effective force, present under arms, of at least 650,000 men; the most formidable which Europe had ever seen assembled in the field. "Ce dévelopement de forces, sans exemple dans les annales modernes," says Jomini, "tenait d'autant plus du prodige, que la nation se trouvait livrée à tous les déchiremens d'une guerre civile, et aux persécutions d'un gouvernement odieux. Mais ce ne fut pas aux levées seulement que ces efforts se bornèrent: tout ce qui compose les élémens de la puissance nationale, avoit été porté à un degré de tension inconnu dans les siècles modernes."[3] Nor did the "prodigy" stop here. In the month of March 1795, France had ten armies in the field, the active force of which amounted to 449,930 combatants, besides 120,850 in garrisons, and 388,450 sick, prisoners, or detached; in all 959,190 soldiers. But the active force, or number present under arms, did not form the half of the effective, and scarcely a third of the complete military strength of France at that period; for, as 200,000 men were still wanting to bring the effective force up to the full establishment, and as the most active measures were in progress to make up the deficit, the total number of Frenchmen under arms in 1795 cannot have fallen much short of 1,100,000 men. It will not be denied, therefore, that the *Comité du Salut Publique* possessed extraordinary energy, and that terrorism proved the salvation of France.

But this state of exertion was too violent to be of long continuance; and neither the population of the country, nor its exhausted resources, were sufficient to maintain so enormous a force in the field. Accordingly, in the succeeding years of the republic, the aggregate of the different armies seldom exceeded 480,000 effective men, and generally fell short of this number. But when Napoleon had mounted the throne, and had organized the system of conscription, he obtained an unlimited command over the whole of that part of the population capable of bearing arms; and as he acted upon the principle, first recommended by Cato, of making war support itself, he was not only able to repair the losses sustained in his various campaigns, but, on most occasions, to take the field with a predominating superiority of numbers. The establishment of the French army, in 1805, amounted to 341,412 infantry of the line, 100,130 light infantry, 77,488 cavalry, 46,489 artillery, and 5445 engineers; making a total of 650,964 men, or a force equal to that organized by the terrorists in 1794 and 1795. But this establishment was afterwards greatly increased; and it is calculated that, at the time of the Russian campaign, there were in the depôts, in the hospitals, and in the field, not less than 1,200,000 men, of whom about 850,000 might be considered as effective. Hence, we are enabled to account for the extraordinary phenomenon of Napoleon's appearance in Germany at the head of a new and formidable army, within a few months after the annihilation of his veteran masses amidst the steppes, snows, and frosts of Russia, and making head for more than a year afterwards against the utmost efforts of the allied powers.

One of the first cares of the Bourbons, on their second restoration in 1815, was to re-model the army, and place it on a footing adapted to the new order of things. The most obvious maxims of policy recommended a proceeding which alone could give stability to the restored dynasty. But such changes are necessarily the work of time; and we need not therefore wonder that nearly ten years should have elapsed before this important object was accomplished. The French army was re-organized, augmented, and placed on nearly the same footing on which it now stands, in virtue of three royal ordonnances, dated the 27th February 1825; the first of which relates

[1] *Guerres de la Révolution, ubi supra.*

[2] *Ibid.* tom. i. p. 224–25.

[3] *Ibid.* tom. v. p. 29.

to the infantry, the second to the cavalry, and the third to the artillery and engineers.[1] The actual military establishment of France has been deduced partly from these documents, and partly from others of a more recent date, containing particulars of the modifications and changes subsequently introduced.

The *infantry* is composed of 6 regiments of the guards and 64 of the line, 20 regiments of light infantry, and 7 foreign regiments; in all 97 regiments. Each regiment consists of a staff and three battalions, and each battalion of eight companies, viz. one of grenadiers or carabineers, another of voltigeurs, and six of fusileers or chasseurs. The peace establishment of a battalion was fixed by the ordonnance of the 27th February 1825 at 600, and the war establishment at 900 men; nor has any very material change since taken place. The staff of all the regiments of the guard and of the line consists, in time of war as well as peace, of a colonel, a lieutenant-colonel, three *chefs-de-bataillon*, a major, three adjutant-majors, a paymaster, a superintendent of clothing, a standard-bearer, a chaplain, a surgeon-major and two assistants; in all 16 officers. The officers of companies, 72 in number, consist of 6 captains of the first class, 18 of the second, 12 lieutenants of the first class, 12 of the second, and 24 sub-lieutenants or ensigns. The total of non-commissioned officers in a regiment of the guards amounts to 380, in one of the line to 259; while the entire strength of both, including officers, non-commissioned officers, and soldiers, is very nearly the same.

The *cavalry* is composed of 2 regiments of grenadiers, 2 of cuirassiers, 1 of dragoons, 1 of chasseurs, 1 of lancers, and 1 of hussars, forming the two divisions of the royal guard; and of 2 regiments of carabineers, 10 of cuirassiers, 12 of dragoons, 18 of chasseurs, and 6 of hussars of the line. Each of the regiments of cavalry of the guard and of the line is composed of a staff and six squadrons. The staff consists of the colonel, a lieutenant-colonel, *chefs d'escadron*, major, instructor-in-chief, adjutant-majors, paymaster, superintendent of clothing, standard-bearer, chaplain, surgeons, captains, lieutenants, and sub-lieutenants, 65 in all. The non-commissioned officers amount to 167 for war, and 163 for peace; and the entire strength of a regiment of the guards is 940 and 748, of a regiment of the heavy cavalry 926 and 734, of a regiment of light cavalry 1022 and 734, for war and peace respectively.

The *royal corps of artillery* is composed of an appropriate staff, of artillery troops attached to the royal guard, and of artillery troops of the line. The staff consists of 390 officers, including the general officers, inspectors of this arm, who also form part of the general staff of the army,—and of 560 *employés*. The officers composing the staff are, 1 lieutenant-general, inspector-general of the central service; 9 lieutenants-general; 16 major-generals; 36 colonels, directors of artillery, inspectors of establishments, commanding *en second* the military schools, and attached to the general direction of the powder manufactories and to the central depôt; 86 lieutenant-colonels, sub-directors, heads of establishments, and adjuncts to the commandants of schools and the central depôt; 72 *chefs-de-bataillon*, sub-directors, heads of establishments, adjuncts to the central depôt and to the ministry, commanding the artillery in fortified places, and aides-de-camp; 110 captains, heads of establishments or acting under them, adjuncts to the central depôt and to the ministry, commanding the artillery in places of strength, and aides-de-camps; 60 in fixed residence; and 50 sub-lieutenants, pupils. The *employés* consist of 1 examinator of artillery; 10 professors of mathematics, and 10 tutors in the same branch; 11 professors of design; 15 master artificers; 290 artillery guards, viz. 16 of the first class, 64 of the second, and 210 of the third; 103 workmen; 31 controllers of the manufacture of arms, and 38 of management; 36 accountants; 3 controllers of the founderies, with 3 assistants; and 3 controllers of the forges, with 3 assistants. The troops of the artillery of the guard form a brigade under the orders of a major-general of the corps, who is permanent inspector; and this brigade is composed of one regiment of foot, one of horse-artillery, and one of the train. A regiment of foot-artillery is composed of a staff, of eight companies of cannoneers, and of a detachment of workmen; amounting in all to 916 and 668 for war and peace respectively. A regiment of the horse-artillery is composed of a staff and 4 companies of cannoneers, or 454 and 382 respectively as above. A regiment of the train of artillery is composed of a staff, with 12 companies in time of war and 6 in time of peace, or 1474 and 524 respectively. Eight *employés* are specially attached to the artillery of the guard for the service of the school and the direction of the matériel, viz. a professor and a teacher of mathematics, a master artificer, three guards, and one principal workman. The artillery of the line is composed of 8 regiments of foot, 4 regiments of horse-artillery, 1 battalion of a pontoon-train, 12 companies of workmen, 1 of armourers, and 8 of the train. Each of the 8 regiments of foot-artillery consists of a staff and 20 companies; each of the regiments of horse-artillery of a staff and 8 companies. The pontoon-train is divided in 12 companies; and each of the 8 squadrons of the train is composed of a staff with 16 companies in time of war, and 8 in time of peace.

The *corps of engineers* consists of three regiments, each composed of a staff and three battalions, with a skeleton company as a depôt, while each battalion is formed of 8 companies, 2 of which are miners and 6 sappers. The regimental staff of each regiment of engineers consists of 1 colonel, 1 lieutenant-colonel, 4 *chefs-de-bataillon*, one of which is commandant of the regimental school, 3 adjutant-majors, 1 paymaster, 1 superintendent of clothing, 1 standard-bearer, 1 chaplain, 1 surgeon-major, 2 assistants, and 3 professors attached to the regimental school; in all 16 officers. The sub-officers and workmen are 23 in number; the strength of a company of sappers or miners is 102 in peace and 150 in war; while that of a regiment, including the *cadre de la compagnie de depôt*, is 2604 and 3756 respectively.

It follows, then, taking the totals of the different corps d'armée conformably to this analysis, that the peace establishment of the French army is fixed at 280,270 infantry and 57,057 cavalry; and the war establishment at 395,500 infantry and 105,347 cavalry. In point of fact, however, the effective force of 1826 consisted of no more than 227,667 infantry and 47,834 cavalry.[2] Nor have these respective numbers been since materially increased; for the effective force of 1829, as estimated in the budget of that year,[3] amounted only to 232,367 infantry and 47,258 cavalry; while, in the budget for 1830, the infantry is estimated at 231,597, and the cavalry at 46,416. But some important changes have taken place since the revolution of July 1830.[4] The Swiss guard has been discharged; the *garde royale* has been dissolved; and the whole of the

[1] *Bulletin des Sciences Militaires*, tom. ii. p. 153. See also tome v. p. 117, and *Annuaire de l'Etat Militaire de France pour l'année* 1828.
[2] *Budget des Depenses du Ministère de la Guerre pour l'Exercise de* 1826. Paris, 1825, 4to.
[3] See abstract of the budget in the *Bulletin des Sciences Militaires*, tom. v. p. 177.
[4] See budget in the *Bulletin*, tom. vi. p. 343.

garde du corps has been broken up. The effective force of each regiment of infantry of the line has also been fixed at 1500, of each regiment of cavalry at 700, and of each regiment of artillery and engineers at 1200 men. This may at first sight appear a considerable reduction; but if we take into account the numerous battalions of national guards which have been organized since the expulsion of the elder branch of the Bourbons, we shall find that the reduction is more apparent than real.

The French army is at present recruited partly by voluntary enrolment for a term of years, and partly by requisitions; in other words, on nearly the same principle which obtained before the revolution of 1790. The system of requisition is of course subsidiary or supplementary to that of voluntary enlistment; but, in the event of another war, it would unquestionably become the principal, if not the only, resource of the army. And this applies to other nations as well as to France. Modern manners, customs, habits, and pursuits, are primarily adverse to the military service; and this opposition can only be overcome by a conscription of one kind or other. Napoleon laid it down as a principle, "que la conscription est le mode de recrutement le plus juste, le plus doux, le plus avantageux au peuple."[1] But without being prepared to go this length, it may be admitted that it is equal in its operation; that its results are certain; and that the supplies it furnishes are of the best quality: whilst voluntary enlistment is at best a precarious resource, and sends to the ranks little else than the scum and dregs of the people. At the same time, the French army, as at present constituted, bears a much smaller proportion to the entire population of the country, and is consequently less burdensome, than that of any other nation of Europe, England only excepted. Russia, for example, requires one man in 97 for her peace establishment, and one in 57 for war: Austria takes one in 60 during peace, and one in 40 during war: Prussia, maintaining a war establishment in peace, withdraws one man in 22 for the service of her army: whilst France requires only one in 137 for peace, and one in 80 for war.[2] The peace establishment of Great Britain presses even more lightly upon the general mass of the population; but, in the event of a war, the proportion would, all in probability, become as unfavourable for the people as that of the French conscription under Napoleon, namely, one in 33 or 34. Such, at least, was the case during the greater part of the last war, particularly after the rupture of the short-lived peace of Amiens.

The national character of every people is commonly developed in a very striking manner by its army. "The Frenchman," says Count Bismark, "courageous, impetuous, nay, even terrible in attack, does not possess that cold-blooded, quiet circumspection and endurance which is so indispensable in a defensive war;" and hence he concludes that a war against the French ought to be carried on *offensively*. "A cautious but not the less uninterrupted offensive, must be the ruling principle in all projects of operation against the French."[3] Major Beamish delivers a similar opinion. "The French," says this officer, "have, with much judgment, generally endeavoured to become the *attacking* party. They thus not only derived the usual advantage of that system, but adopted the mode of warfare which was peculiarly suited to their national character. The French soldiers are impetuous; but their courage requires excitement, to which *motion* so much contributes. Abstract motion, however, is not sufficient to impel the French soldier into action: he must be first excited by the example of his officer; and were it not for the extreme and universal gallantry displayed by the officers of the French army, few instances of impetuous courage would be recorded on the part of the men. It has been said that 'the French officers will always lead, if the men will follow;' and there have been instances where the former have nobly sacrificed their lives to produce this effect"[4] General Foy, whose endeavours to depreciate the British are at such variance with the better points of his character, says that "to Frenchmen you must always speak," and that "the intoxication of the French is gay, sparkling, and daring; a foretaste to them of the battle and the victory."[5] A still higher authority confirms these opinions. "Le Français, naturellement brave, actif, et impétueux," says Baron Jomini, "fait aisément des conquêtes, mais il les perd avec la même facilité. Dès qu'il cesse de marcher en avant, une sorte de dégoût s'empare de lui; il est difficile de le contenir. Depuis la révolution, surtout, cette disposition s'était accrue de plus en plus: les liens de la discipline ne retenant plus le soldat, il était devenu mutin, raisonneur, et indocile."[6] Colonel Napier's opinion appears substantially to coincide with that of Jomini and other competent judges.[7] In fact, no military nation of Europe has gained so many splendid victories, and sustained so many disgraceful defeats, as the French; whose whole history, indeed, consists of an extraordinary alternation of the most brilliant successes and the most calamitous reverses, of triumphant ascendancy and abject humiliation. "Aucune nation," says Guibert, "n'a perdu de batailles aussi honteuses, aussi décisives, que la nôtre; aucune n'en a gagné si peu de décisives et de complettes."[8]

Spanish army.

The Spanish army, which, under Charles V., Pescaira, the Duke of Alba, and the Constable of Bourbon, had proved itself so formidable—extending the theatre of its exploits from the Pyrenees to the Po and the Adige on the one hand, and to the Elbe, the Meuse, and the Waal on the other—degenerated rapidly under the disastrous reigns of the last princes of the House of Austria. When Philip V. ascended the throne at the beginning of the last century, it scarcely amounted to 15,000 men. By that prince and his successors, however, it was gradually increased, until, in the year 1792, its establishment amounted to 116,000 infantry, 12,200 cavalry, with upwards of 10,000 artillery, and its effective force to about 120,000 men of

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[1] Napoleon having established "qu'un million d'âmes fournit chaque année 7000 à 8000 conscrits, et que les besoins de l'administration et des divers états n'en réclamait que moitié," he therefore concluded, "qu'une levée annuelle de 3500 hommes n'offrait, deduction faite des morts, que 30,000 hommes en dix ans," or about a 33d part of the entire population. (See Rogniat, *Réponse aux Notes Critiques de Napoleon*. Paris 1823.) But the draughts on the population of France were never carried to the full extent of the principle, and seldom exceeded one in 43 or 44.

[2] *Mémoire sur l'Organisation de la Force Militaire de la France*, p. 38. Dijon, 1825.

[3] *Cavalry Tactics*, p. 336, Engl. transl.

[4] See Major Beamish's Note to the passage in the *Cavalry Tactics* above quoted.

[5] *History of the War in the Peninsula under Napoleon*, vol. i. p. 158, Eng. transl.

[6] *Histoire Critique et Militaire des Guerres de la Révolution*, tom. iii. p. 125.

[7] Napier, *History of the War in the Peninsula*, vol. i. p. 10. See also vol. iii. p. 329, where, in describing the attack of the British position on the crest of the Sierra de Busaco, 27th September 1810, Colonel Napier renders justice to the "astonishing efforts of valour" on the part of the French, and ably discriminates the respective characteristics of the troops engaged on that occasion. The onset of the French was truly terrible, and at one moment had very nearly succeeded.

[8] *Essai Général de Tactique*, tom. i. p. 176.

Army.

all arms. At present its effective amounts to 90,000, and its disposable force to 75,000 combatants. It is composed of the general active staff, of the staff of the fortresses, of the household troops and royal guard, of the infantry and cavalry of the line, with artillery, engineers, and veterans. Its staff consists of 6 captain-generals, 77 lieutenant-generals, 122 major-generals, 350 brigadier-generals, with inferior officers in proportion. There are 15 captaincies, viz. 12 territorial and 3 colonial. In Spain, and its possessions contiguous to the Peninsula, there are 150 fortresses, posts, forts, citadels, or open towns where troops are in garrison. The household troops consist of six squadrons of the body guard and a company of halberdiers: of these four squadrons are Spanish, and two foreign, called Saxons, in honour of the queen. The royal guard is organized like that of France, and consists of two divisions of infantry, one division of cavalry, and three companies of artillery, one of which is horse-artillery. The first division consists of four regiments of grenadiers, each composed of two battalions, divided into eight companies of 120 men each; and the second of two regiments of the élite of the provincial militia, divided into three battalions of four companies each. The cavalry forms a division of two brigades; and the artillery consists of three companies of 100 men, each serving a battery of six pieces mounted. The infantry of the line consists, first, of 10 regiments of three battalions each; secondly, of the Swiss regiment Wimpffen, one battalion only; thirdly, of a regiment, fixed at Ceuta, composed of four companies of 100 men each, the refuse of the army. Seven regiments, of two battalions each, of the same number and composition as those of the line, form the light infantry. The militia consists of 42 regiments of one battalion each, which is divided into eight companies. The cavalry consists of 13 regiments, of which 5 are of the line, and 8 light horse, each of four squadrons, composed like those of the royal guard; together with two companies of cuirassiers at Ceuta, one formed of native Spaniards, and the other of Moors. The royal corps of artillery is divided into the theoretical and practical. The troops of this arm consist, first, of 6 battalions of foot artillery, in garrison at Barcelona, Carthagena, Seville, Corunna, and Valladolid; secondly, of 4 companies of horse-artillery, in garrison at Carthagena and Seville; thirdly, of 5 companies of artificers; fourthly, of 5 battalions of the train; fifthly, of 3 brigades and 15 companies fixed in garrison, but exclusive of the *personnel* in America. This arm has a splendid museum at Madrid, besides a theoretical and practical school, directed by a brigadier-general or colonel, in the principal town or place of each province. The engineers are a corps of officers not regimented or brigaded, consisting of an engineer-general, 10 directors sub-inspectors, 17 colonels, 20 lieutenant-colonels, 34 captains, and 56 lieutenants; together with a regiment of sappers, consisting of 2 battalions of 8 companies each, viz. 5 of sappers, 1 of miners, 1 of pontoneers, and 1 of workmen. The establishments of this arm are, a topographical depôt-general, or collection of maps, plans, and military memoirs; a museum, containing representations in relief of the fortresses, and different models of fortifications; and an academy for the instruction of young officers intending to enter this branch of the service, after they have passed through the primary school of Segovia. All these establishments are situated in the capital.

The Spanish army is recruited by voluntary enrolment, and, in case of insufficiency, by ballot or conscription. The term of service is eight years for the first enrolment or ballot, and two or four for the second, when the soldier becomes entitled to an increase of pay. Before the war of independence no one could attain the rank of officer without having been a cadet; and each cadet was bound to prove his nobility. But since the return of Ferdinand these proofs have been dispensed with, and serjeants now obtain a third of the sub-lieutenancies; the other two thirds being reserved for the *élèves* of the military school of Segovia, who have passed the customary examinations at the end of their course of study. The dress and equipment of the Spanish army are in the worst state; the pay of the troops is exceedingly irregular; and their discipline is, in consequence, as bad as it is possible to imagine, or rather, there is scarcely such a thing known.[1] "L'Espagnol, sobre, vigoreux, infatigable," says Jomini, "possède de grandes vertus guerrières, mais il manque d'activité soutenue. Si dans ces dernières révolutions, son caractère se soumit difficilement à la discipline, nous avons été induit à penser, en observant l'esprit du peuple, que dans les temps ordinaires, il y serait plus facilement ployé. Son courage tumultueux prêtait beaucoup à une prompte désorganisation, car la déroute est toujours compagne de cette disposition naturelle des esprits chez les peuples méridionaux."[2] In a word, the Spaniards afford a striking illustration of the truth of Napoleon's maxim, that *in war the moral is to the physical force as three parts to one.*

Portuguese army.

After the general peace of 1814, when all the powers of Europe had reduced their military establishment, Portugal alone did not follow their example, but fixed the peace establishment of its permanent army at 49,268 infantry and 5230 cavalry; which, with the militia, made a force of 59,325 men, or about 22 soldiers for every 100 inhabitants. Such a state of things, however, was much too violent to be durable. Accordingly, one of the first cares of the constitutional government of 1821 was to reform a military system so disproportionate to the population and the financial resources of the kingdom. The armed force since that period has therefore consisted exclusively of the permanent army and the militia. The permanent army is composed of a general staff, an engineer corps, 24 infantry regiments of the line of one battalion each, 6 regiments of *chasseurs à pied*, and 12 regiments of *chasseurs à cheval* of 3 squadrons each, 4 regiments of artillery, a battalion of engineer artificers, a company of soldiers of the train, a police guard, and 30 companies of veterans. The general staff consists of an indeterminate number of lieutenant-generals, 16 major-generals, 24 brigadier-generals, 6 superior officers, 6 subalterns, 12 aides-de-camp, 12 secretaries, 10 employés, and a veterinary surgeon-in-chief; in all 100. The engineer corps (*corpo de engenheiros*) is composed of 4 colonels, 4 lieutenant-colonels, 8 majors, 12 captains, 12 lieutenants of the first class, and 12 of the second; in all 64. Each regiment of infantry of the line and of light troops consists of 44 officers and 780 non-commissioned officers and soldiers. The effective strength of a regiment of artillery is 551 men, including 33 officers. The corps of the train of artillery (*artilheros conductores*), reduced to a single company by the organization of 1821, is composed of 12 officers, 30 soldiers, and 70 mules (*bestas muares*). The battalion of engineer artificers consists of

[1] *Notice sur l'Armée Espagnole*, redigée sur *El Estado Militar* de 1828 et sur un manuscrit. Paris, 1829. *Bulletin des Sciences Militaires*, tom. v. p. 420. With regard to the present state of discipline, or rather of indiscipline, of the Spanish army, the author of the *Notice* observes, "La discipline n'a jamais subsisté dans l'armée Espagnole. Ce n'est pas qu'il manque de réglement; il en existe un fort étendu, redigé avec soin d'après le nôtre (le Français) de 1792; mais c'est un frein qu'on n'a pu jusqu'ici amener l'Espagnol à supporter. Au respect près que le soldat a pour son officier, il n'y a pas l'ombre de discipline."

[2] *Histoire Critique et Militaire des Guerres de la Révolution*, tom. i. p. 242.

201 men, including 12 officers. Each of the 30 companies of veterans is from 70 to 80 strong, including 2 officers. The police guard of Lisbon consists of a battalion of infantry of 8 companies and 980 men, including officers; together with a battalion of *gens d'armerie à cheval* 238 strong, divided into 4 companies. The effective force of the permanent army on the peace establishment is therefore 29,645 foot, and 4411 horse. But the events of which Portugal has since 1821 been the theatre, and the circumstance of six battalions having been sent to Brazil, render it probable that, at the period of the insurrection of the Marquis de Chaves, the regular army did not exceed 24,000 or at most 25,000 men. The militia form 48 regiments of infantry, of the same strength and composition as those of the line; together with six separate corps, of which three are infantry, two cavalry, and one artillery; amounting in all to 38,542 men, and, with the army of the line, making the total of land forces 68,187 men of all kinds and arms. The *ordinenzas*, which formed 441 legions or *capitanea mores*, were abolished by the Cortez in 1822, to the great satisfaction of the nation, which justly regarded this institution as a most grievous scourge. They were a sort of levy *en masse*, which all individuals between the age of 16 and 60, unless serving in the regular army or in the militia, might be called upon to join at the shortest notice. The army, which is indebted for its organization to marshal Beresford, is well disciplined and instructed. Its equipment and arms are the same with those of the English troops.[1]

Austrian army.

At the period when the emperor of Germany engaged in war with revolutionary France, the Austrian army was on a very effective footing, both in regard to organization and numbers. The infantry, it is true, though well trained and disciplined, wanted vivacity, and its physical was superior to its moral force. But the cavalry, which was composed of admirable materials, rivalled the Prussian squadrons in instruction, and surpassed them in other particulars. The artillery and engineers were also good, although the *matériel*, less perfect than that of the French, was either too heavy for pieces in position, or too light for efficient service in the field. Nor was the staff deficient either in erudition or in talents; but its theories were antiquated and vague, resting partly upon the system of cordons attributed to Lascy, and partly also upon certain hypotheses, which it was gravely proposed to put to the test of experiment in the field. At the commencement of the war with France, the imperial army consisted of 232 battalions of infantry and 220 squadrons of cavalry; and as the battalions were very strong, being raised by means of reserves to 1200 men and upwards each, the whole of the Austrian force at this period may be estimated at 240,000 foot, 35,000 horse, and 10,000 artillery.[2] But the reverses it experienced in consequence of an obstinate adherence to a vicious system, and the exigencies of the long and protracted struggle with republican and imperial France, led to successive augmentations of the effective force, until at one time it considerably exceeded 700,000 men of all arms. At the general peace of 1814, however, Austria, exhausted by a war of five-and-twenty years, reduced her military establishments nearly one half; adjusting the scale of peace so as to render it commensurate with that which, it was conceived, France would adopt as soon as the Bourbons felt themselves in a condition to re-organize a permanent force. Several changes, indeed, have since been made; but the account which follows, derived from the most authentic sources,[3] will be found to exhibit a correct view of the actual force and organization of the Austrian army, consisting of the troops of the line, and the *militär-gränzen*, or *military of the frontiers*.

The *infantry*, exclusive of the 17 regiments of the frontiers, is composed of 58 regiments of the line, 1 regiment of chasseurs, 12 battalions of chasseurs, and 5 garrison battalions; besides, in time of war, the infantry of the staff and the landwehr. Of these, 3 are recruited in Lower and 2 in Upper Austria, 5 in the interior and in the Illyrian provinces, 9 in Bohemia, 5 in Moravia, 11 in Gallicia, 4 in the Venetian States, 4 in Lombardy, 12 in Hungary, and 3 in Transylvania. The different regiments are designated respectively by the names of their provinces, and those of the officers who are proprietors therein (*inhaber*). A regiment of the line consists, in time of peace, of a staff, 2 companies of grenadiers, and 18 of fusileers. The companies of fusileers form 3 battalions, each of 6 companies; and 2 companies make a division. In time of war a fourth battalion is organized, called that of the depot, and is composed of 4 companies. The companies of grenadiers form separate battalions, commonly consisting of three divisions or six companies; but there are at present two battalions which have only four companies. The Hungarian and Transylvanian regiments consist, in time of war, of 4 battalions of 6 companies each; and the company contains 200 men. The force of the infantry of the line amounts, therefore, on the peace establishment, to 1044 companies of fusileers and 116 of grenadiers, or 174 battalions of fusileers and 20 of grenadiers; and, during war, to 1134 companies of fusileers, or 189 battalions, and the same number of companies or battalions of grenadiers. By the *military frontiers* are understood the provinces and districts conterminous with Turkey, to the east and south of the empire; which, by reason of the military service, internal as well as external, that their male population is subject to, have an organization entirely military; some districts of Transylvania alone excepted. These military provinces furnish 17 regiments of national infantry, a battalion of *tschaikists* or watermen of the Danube, and a regiment of hussars (*szekler*), who, in as much as they are liable to be called to join the army, really form part of it, but who, in respect of their particular organization, may be considered, in time of peace, as constituting a distinct force. Military Croatia comprehends six districts, each of them furnishing a regiment, which bears the name of the chief place of the district, and consists of 12 companies. The service of these regiments in time of peace is confined to guarding the cordon. The light infantry is composed of the imperial regiment of Tyrolese chasseurs, consisting of 4 battalions of 4 companies each; and of 12 battalions of chasseurs, 4 companies each in time of peace, and 6, with a depôt company, in time of war. A company of chasseurs consists of 195 men, including officers. The garrison battalions, composed of a sort of demi-invalids, unfit for the service of the line, are stationed, 1 in Buckowina, 1 in Esclavonia, 1 in Hungary, 1 in Dalmatia, and 1 in Lom-

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[1] *Notice sur l'Armée Portugaise*, extrait analytique de *l'Essai Statistique sur le Royaume de Portugal et d'Algarve*, par Adrien Balbi. Paris, 1827. *Bulletin des Sciences Militaires*, tom. iv. p. 121. Some alterations have, we believe, been introduced by Don Miguel; but we have not been able to ascertain their nature or extent.

[2] Jomini, *Guerres de la Révolution*, tom. i. p. 232.

[3] The account of the Austrian army, given in the text, is derived partly from the *Allgemeine Militär-Zeitung*, which appeared at Leipsig and at Darmstadt in 1826, partly from the *Constitution de l'Armée Autrichienne* of Bergmayr, and partly also from the *Annuaire Militaire Autrichien*, together with a variety of papers in the *Bulletin des Sciences Militaires*, tom. iv. v. vi. and vii. 1827, 1828, 1829, and 1830.

bardy, and consist each of six companies, with the same complement of officers and non-commissioned officers as the companies of the line. The divisions of infantry of the staff (*stabs-infanterie-division*), are composed in the same manner, and organized, in time of war, for the purpose of guarding the head-quarters and the magazines of the army, and of removing the wounded from the field of battle to the nearest hospitals. The number of battalions of the landwehr is seventy. In each district of country (Hungary, Transylvania, and Italy excepted) assigned for the recruitment of a regiment, two battalions of landwehr are raised and attached to such regiment; the one containing the men who are the least necessary to their families, and the most proper for the service, and the other, the surplus of those who are obliged to form part of the landwehr. The first battalion is exercised fifteen days in the year, the second only eight hours. The commandants receive their orders from the colonel of the regiment of the line to which their battalions are respectively attached. The landwehr is principally destined for the service of the interior; but it may also be sent to an active army. In either case it is paid the same as the troops of the line.

The *cavalry* consists of 8 regiments of cuirassiers, 6 of dragoons, 7 of light horse, 11 of hussars (exclusive of the frontier regiment), and 4 of hulans; together with, in time of war, the dragoons of the staff (*stabs-dragonner*); all raised, like the infantry, in different provinces, viz. 3 regiments of cuirassiers in Bohemia, 3 in Moravia, 1 in Lower Austria, and 1 in Central Austria; 3 regiments of dragoons in Moravia, 1 in Upper and Lower Austria, and 1 in Lower and Central Austria; 1 regiment of light horse in Moravia, 4 in Bohemia, 1 in Gallicia, and 1 in Italy. The hussars of the 11 regiments are all either Hungarians or Transylvanians. The regiments of hulans consist of inhabitants of Gallicia and volunteers. In time of peace, the regiments of cuirassiers and dragoons consist of 6 squadrons, and the other regiments of 8; making in all 260 squadrons. Two squadrons make a division; and, in regiments which have 8 squadrons or 4 divisions, 2 are commanded by the majors. The dragoons of the staff, of which there are several divisions in time of war, have the same destination as the infantry attached to it, and are besides employed in repressing disorders committed by marauders, and in other like services.[1]

The *artillery* is divided into three parts, or distinct corps, viz. the field artillery (*feld-artillerie*); the artillery of the arsenals and magasins (*feld-zeugamt*); and garrison artillery (*garnison artillerie*). The *field artillery* consists of a corps of bombardiers, 5 regiments of field artillery, and a corps of fire-masters. The corps of bombardiers has a staff, and 5 companies of 204 men each, including officers. It is recruited by corporals of artillery, and performs the most difficult as well as important service to the army. A regiment of field artillery is composed of a staff and 4 battalions, one of 6 companies and three others of 4 companies each; making in all 18 companies. A company serves three or four batteries of 6 pieces; and each battery is commanded by a lieutenant or major-firemaster. The train of the army furnishes the horsing of the batteries, which is under the command of officers of that corps, and generally independent of the chiefs of batteries, but subordinate to them in this particular service. The corps of firemasters is established at Neustadt, near Vienna, where it is at present occupied in attempting to fabricate Congreve rockets, we know not with what success. The *artillery of the arsenals and magazins*, consisting of a staff and *personnel* of the necessary workmen, furnishes the field artillery, and the equipages of war, with the requisite arms and munitions, and it guards them when in magazine. The *garrison artillery*, charged with the service in fortresses, is divided into fourteen districts, determined by the provinces, and proportioned in numbers to these districts. The district of garrison artillery of Vienna comprehends an arsenal, containing all the equipage of sieges; and attached to it are a foundery, an establishment for boring cannon, and manufactories of saltpetre and gunpowder.

The *engineer department* comprehends a corps of engineers, with the sappers and miners. The pontoon train is attached to the staff, and is under the direction of an *oberst-schiffamt* or chief of boats. The train or corps of military equipages (*militär-fuhrwesens-corps*) is wholly independent. The engineer corps is composed of 4 generals, 6 colonels, 9 lieutenant-colonels, 18 majors, 42 captains, 30 captains *en second*, 30 lieutenants, 30 sub-lieutenants, and 12 cadets. Each command or military division embraces a district of fortification; consequently there are fourteen such districts, to each of which is attached a director, who is taken from the generals or officers of the engineer staff. In each place there is also an engineer-in-chief, who is an officer of the staff or a captain of engineers; but in Vienna, Milan, Peterwaradin, and Venice, the director performs the functions of chief engineer. The corps of miners is composed of a staff, five companies, and a garrison detachment; and the corps of sappers, of a staff like that of the miners, six companies, and a garrison detachment. The pontoon corps consists of a staff and 2 battalions of 4 companies each. In time of war the number of battalions is three, two of which have 6 companies and one 4; besides a company in depôt. The train or corps of military equipages consists, in time of peace, of 12 divisions of transport (*transports-division*), and 20 sets of horses for field batteries (*exercier-batterie-bespannung*). Each division is provided with 90 horses; and all the detachments of the corps stationed in a province are under the orders of a commandant. In time of war the military equipage train consists of seven principal divisions, viz.: 1. the artillery transport division; 2. that of pontoons; 3. that of flying bridges; 4. that of baking; 5. that of health for the transport of the wounded; 6. that of victualling; and, 7. that of general transport.

Two regiments of the same or different arms form a brigade, which is under the orders of a major-general; and two or three brigades form a division, which is commanded by a field-marshal-lieutenant. In time of war, corps d'armée are organized, each consisting of several divisions, and under the orders of a general of cavalry or artillery, or of the oldest field-marshal-lieutenant. In the Austrian army there are at present 10 field-marshals, 18 generals of

[1] Jomini has particularly remarked the superior composition, organization, and discipline of the Austrian cavalry, which has proved its excellence in many bloody encounters, and, when led with talent, has never failed to distinguish itself. At the battle of Würtzburg, 3d September 1796, Wartensleben passed the Maine with twenty-four squadrons of cuirassiers, attacked the French cavalry under Bonneau, overthrew it, and thus decided the victory. "This brave veteran," says the Archduke Charles, "impressed with the importance of the order which he had received, dashed into the Maine at the head of his cavalry, and swam across." "This manœuvre," he adds, "was completely successful: the French cavalry, which had awaited the charge without stirring, was overthrown." At the battle of Leipsic, the Austrian cuirassiers, commanded by Nostitz, "covered themselves with glory." On the 16th October, at one o'clock in the afternoon, Nostitz, having scarcely passed the Pleisse at Gröbern, attacked the lancers and dragoons of the French imperial guard, overthrew them, and then broke several squares of infantry. Other instances of a similar kind might be mentioned.

cavalry and artillery, 67 field-marshal-lieutenants, and 118 major-generals, in actual service; 9 generals of cavalry and artillery, 30 field-marshal-lieutenants, and 92 major-generals, unemployed. The guards form no part of the army. They are divided into the noble body guard of arquebusiers, the Hungarian body guard, the guard called *trabans*, and the civic guard. The military institutions of the first order consist of the company of cadets at Olmutz, that of Gratz, the military academy for cadets at Vienna, the five regimental schools of artillery, the school of bombardiers, and the academy of engineers. The total of the peace establishment of this army is 270,000 infantry and 50,000 cavalry, with a reserve of 250,000; while its war establishment, which can be organized in four months, may be estimated at 750,000 infantry and from 70,000 to 75,000 cavalry.

Prussian army.

At the death of Frederick the Great, the army of the Prussian monarchy, amounting to about 200,000 combatants, was accounted the best of Europe. Proud of a struggle without example in modern annals, and of the superiority of the genius of their king, the victors of Leuthen, Rosbach, and Torgau added to this force of opinion an instruction in great manœuvres, which the troops of no other nation approached, much less rivalled.[1] The successor of Frederick, to whom this superb army descended, though possessed neither of his genius nor his ambition, was at great pains to maintain the reputation which it had acquired; and some laurels that had been easily gathered in the Low Countries seem to have inspired him with the notion that it was still capable of equalling, perhaps surpassing, the brilliant achievements which had established its renown. In this spirit, and, doubtless, believing that the French nation might be reduced with the same facility as the insurrection in Holland, the Prussian monarch put himself at the head of the confederacy formed to crush a people who had risen in arms to assert their liberties and preserve the integrity of their territory. But the issue proved how much he was at fault in his calculation. For a mercenary and mechanical army, however perfect its discipline and instruction may be, can never triumph over a generous people, inspired by patriotism, endowed with high military qualities, and resolved to conquer or to die in defence of their liberties. Besides, the Prussian army of this period[2] was not a national one, nor was it animated by a common feeling. The half of it, as at Frederick's death, was still composed of deserters from all nations, or volunteers enlisted in every circle of the empire:[3] it was neither inspired by the genius of its chief, nor excited by any feeling calculated to improve its moral force: discipline formed the only tie by which it was held together. Nor was it long ere its inferiority was proved, and its pride severely humbled. The affair of Valmy opened the king's eyes; and henceforth, more docile to the suggestions of prudence, he negociated for permission to withdraw to the right bank of the Rhine the wrecks of that army the glory of which had just been eclipsed in the plains of Champagne by battalions of youthful volunteers. He had been taught a lesson by which he did not fail to profit; and after the unsuccessful campaigns on the Rhine, he sneaked ingloriously out of the contest which he had been so eager to commence; leaving the empire and Austria to the undivided resentment of the conquerors. But he re-established his army, while his late ally was maintaining a death-struggle. The parades and manœuvres of Potzdam were resumed with their wonted éclat; confidence revived; and Frederick began to flatter himself that he alone could re-adjust the disturbed equilibrium of Europe. He failed, however, to observe the prodigious development which the military art had received in the course of the revolutionary war; or at least he neglected to profit by the discoveries to which it had given birth: and, as he had formerly deserted his ally at the beginning of the contest, so now he took the field just at the moment when that same ally was being overthrown at Austerlitz, and compelled to accept the terms dictated by the conqueror. And at Jena as at Auerstadt, at Halle as at Lubec, he paid the price of his procrastinating folly. But misfortune, a rough school-mistress, had inculcated some useful lessons. The military constitution of Prussia was changed; foreign recruitment ceased; a national army was formed; the privileges of the nobles were abridged; old institutions were reformed; discipline was improved by being simplified; the arming and equipment of the army were improved in all their branches; the best parts of the French military system were adopted; the patriotism of the nation was roused; in short, during five years, Prussia was silently but actively employed in preparing those elements of strength which, in 1812, delivered the monarchy from the yoke of the stranger, and re-established her at the head of the second-rate powers of Europe.

The armed force of the Prussian monarchy is composed, first, of a permanent army; secondly, of a war reserve or *landwehr* in two bans; thirdly, of a *landsturm*, or sedentary national guard. The permanent army is composed of young men of family who are destined to the profession of arms, and are named officers after undergoing certain examinations; of volunteers who clothe, equip, and support themselves for a year at their own charge; of persons between the ages of 17 and 40 who enlist voluntarily and receive regular pay; of a part of the youth from 20 to 25 years of age, raised by means of requisition; and, lastly, of veterans or soldiers who consent to remain in the service beyond the term prescribed by the law. The *infantry* consists of 36 regiments of 3 battalions and 9 regiments of 2 battalions, besides six battalions of chasseurs and carabineers, forming in all 132 battalions; the *cavalry*, of 38 regiments of 4 squadrons each, 10 of which are cuirassiers, 5 dragoons, 13 hussars, and 10 hulans, in all 158 squadrons;[4] the *artillery*, of 9 brigades, each consisting of 3 companies of horse, 12 of foot artillery, and 1 of artificers; and the *gens-d'armerie*, of 8 brigades, divided each into 2 detachments.[5] All the youth who have not served five years

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[1] *Guerres de la Révolution*, tom. i. p. 228. Notice sur le Système Militaire de la Prusse, *Bullet. des Scien. Milit.* tom. iii. p. 417, 461, 541, et tom. v. p. 417. See also *Archiv für neuere Kriegs und Armee Geschichte*, vol. i. part 1st, and *Zeitschr. für Kunst, Wissenschaft, und Geschichte des Krieges*, part 2d, 1817.

[2] At the commencement of the French Revolution the Prussian army consisted of about 120,000 infantry, 35,000 cavalry, and from 7000 to 8000 artillery, with a most respectable corps of engineers. (*Guerres de la Révolution*, i. 232.) In 1806, it amounted to 260,000 men of all arms. (*Etat Comparatif de l'Armée Prussienne en* 1806 *et en* 1827. *Bullet. des Scien. Milit.* tom. v. p. 417.)

[3] Jomini reckons the number of foreigners serving in the Prussian army at this period at only *a third part* of its entire strength; but we agree with the author of the *Notice sur le Système Militaire de la Prusse* in thinking it amounted to a half. The data on which this conclusion is founded appear amply to warrant the statement made in the text. (*Hist. Crit. et Milit.* i. 233.)

[4] The Prussian cavalry, in the time of Frederick, was confessedly the best in Europe. "L'infanterie Prussienne," says Jomini, "quoique manœuvrière, était cependant loin d'atteindre le degré de perfection auquel Seidlitz avait porté le cavalerie: cette dernière arme tenait alors le premier rang en Europe. (*Hist. Crit. et Milit.* i. 231. See also *Cavalry Lectures*, p. 329.)

[5] The gens-d'armerie is of three kinds: the *armée gens-d'armerie*, divided into detachments stationed at the head-quarters of generals of corps-d'armée; the *land gens-d'armerie*, consisting of 80 wachtmeister and 1240 gens-d'armes, of whom 1080 are mounted; and the *grænz-gens-d'armerie*, which assists the employés of the customs in discharging their duties on the frontiers.

in the active army or in the reserve form part of the *first* ban of the *landwehr*, until they attain the age of 30 years complete. The *second* embraces those from 32 to 40 years of age; and both classes, during time of peace, remain at home, pursuing their ordinary avocations. But, in the event of war, the first ban is destined to reinforce the permanent army; and the second, to form the garrisons of strong places, and even, in case of need, to send detachments to the army in the field. The *landwehr*, like the permanent army, is composed of infantry, cavalry, and artillery. In the year 1827, the infantry of the first ban consisted of 116 battalions, and the cavalry of 104 squadrons. Hence, if we include 54 garrison companies, and 18 of invalids at Berlin, Stolpen, and Rybnik, the total of the peace establishment of the Prussian army will amount to 122,000 men, while that of war would not be less than 250,000 men of all arms: and such is the admirable military organization of the country, that two months only are necessary to raise the army to the full complement of the war establishment. In Prussia the cavalry is a preponderating arm. Of the 122,000 men composing the peace establishment, 37,000 belong to this branch of the service. The *landsturm* is a levy *en masse* of men from the age of 17 to that of 50, and, in cases of imminent danger, it is called out by a royal ordonnance. It is formed into urban and rural companies, and, like the French national guard, performs, if necessary, the duties of the interior; thus leaving the whole of the permanent army and the *landwehr* available for the service of the field. The actual constitution of the Prussian army is strictly economical in all its parts, and the number of military functionaries is reduced to the lowest possible scale consistent with the efficiency of the service. In Prussia every man who wears a uniform works hard for his money.

All Prussians, from the age of 20 to 50, are held liable to military service, but they only serve regularly from 20 to 26. The duration of service is consequently fixed at five years; but, in time of peace, the requisitionary youth remain only the first three years under their colours, after which they return to their homes, and are not called out again, except for a few weeks towards the expiry of the fifth year, when they are inscribed in the *landwehr* of the first ban. The population of Prussia being 11,500,000 souls, about 98,000 males will annually attain the twentieth year of their age. Hence, if we deduct 38,000 for such as are excepted from military service on account of their age or their status in society, the total number of disposable persons, between the age of 20 and 25, will amount to 395,000. And if to this we add that portion of the male population from 25 to 32 years of age who are eventually called to the service, it will follow that Prussia, without having recourse to the second ban of the *landwehr*, could raise 900,000 men trained to the use of arms; while France, even since 1824, when the re-organization of her army commenced, could scarcely bring into the field more than 480,000 men, of which the one half would be nearly uninstructed in the use of arms. The annual renewal of this army by thirds renders it necessary to push, with the utmost activity, the instruction of both infantry and cavalry, and to pay little regard to that martinet precision which formerly characterized the Prussian tactics, but which is of so small use in the presence of an enemy. The showy on parade has consequently been sacrificed to the useful in the field; and the mere foppery of war has given place to movements and evolutions, which are recommended alike by their simplicity, and by the testimony which experience, the best of all instructors, has borne in their favour. So long ago as the year 1808, the degrading discipline, introduced by the father of Frederick the Great, was abolished by the *kriegs-artikel* or the martial law; and military punishments are now principally confined to hard drills, confinement of various degrees, retrogradation in rank, and some others of a still milder description. Finally, the first grades are the reward of merit established by examination, and as such open to all; while, from the rank of sub-lieutenant to that of general, and even beyond it, seniority, that conservative law of acquired rights, regulates the advancement of officers, and ultimately insures the veteran his reward. Thus, after sustaining the greatest disasters, the Prussian army has survived its dispersion in 1807, and risen, as it were out of its ashes, stronger and better constituted than at the period when it was so rashly opposed to the undivided power of France, wielded by the masterhand of the greatest warrior of modern times. "Heureux les gouvernemens," says a French military writer, "auxquels les malheurs servent de leçons!" Nor would their "happiness" have been much diminished had such governments remembered in victory the promises made to the people in misfortune, and shown but half as much zeal to improve *their* condition as to rectify the defects of their military systems.

Russian army.

At the period of the emperor Alexander's death, the distribution of the Russian and Polish forces was that of an army ranged in order of battle, with its front facing the west. 1. The advanced guard of this army was formed by the Polish army and the corps d'armée of Lithuania; presenting a mass of 80,000 combatants, under the command of the grand duke Constantine. In point of mechanical instruction, no army in Europe could be compared to it. Disposed in cantonments of about 150 leagues in length, from Lowicz to Minsk, and 146 in breadth, between Kowno and Dubno, it could be concentrated, at Warsaw or at Brzecs-Littowsky, in less than three weeks. 2. The army of the right was composed of the corps d'armée, cantoned in Courland and Livonia, of the corps of the guard, and of the first corps of the cavalry of reserve; which, united, formed also a mass of 80,000 combatants. These were perhaps the only troops which, in point of mechanical perfection, rivalled the army of the advanced guard under Constantine. Their cantonments extended from Polangen to Pleskof, about 132 leagues, and from Revel to Wilkomirsz; and eighteen days at the most were sufficient for assembling them on the Niemen. 3. The army of the left, denominated the second army, was equally formed of a mass of 80,000 combatants, cantoned in the Chersonesian governments. The greatest depth of its quarters, from Choczym on the Pruth to Czerkasy on the Dnieper, was about 106 leagues; and the greatest breadth 180 leagues, between Machnowka, near the southern frontier of Volhynia and Simpherapol in the Crimea. Three weeks were necessary for concentrating it on the Pruth. 4. The army of the centre, called also the first or grand army, formed a mass equal to the three preceding armies, and consequently consisted of 240,000 combatants. Its cantonments extended on one side to more than 234 leagues, or from Kaszin, on the frontier of the government of Tver and of Jaroslaf, as far as Saratow; and, on the other, to upwards of 320 leagues, from Ostrog to Moroum, on the frontier of the government of Vladimir and of Nijei-Novogorod. It required six weeks at least for concentrating itself in the province of Volhynia. 5. Besides these four armies, consisting of 480,000 men, Russia had also several corps, of various descriptions, amounting to more than 267,000 men; viz. the corps of Finland, of Orenburg, and of Siberia, 45,000 strong; the corps of the Caucasus, 85,000; the military colonies, 67,000; and the troops in garrison, 70,000: thus making a grand total of 747,000 men, exclusive of the Kirgishes, Baschkirs, and other Tartar hordes, of whom from 250,000 to 300,000 may in case of exigency be brought into the field. The whole mili-

tary force of the Russian empire, at this period, may, therefore, be estimated at about a million of men, or a forty-ninth part of the entire population; while the country, as we have just seen, was organized into one vast camp, arranged upon strategic principles, so as to render the transition from a state of peace to a state of war easy and expeditious, and, with formidable means of aggression, to combine defensive resources of almost incalculable extent.[1]

The contest with Turkey in 1828 and 1829 produced no sensible derangement of this system, and only altered for a time the relative proportions in the numbers of the four principal armies, according as troops were moved upon the various strategic points in the theatre of war. But the *lacunæ* created by the casualties of the two campaigns in Moldavia, Bulgaria, and Rumelia, have been already filled up; and consequently the above account of the military organization and force of the Russian empire is as applicable in 1831 as it was from the death of Alexander in 1826 to the commencement of the Turkish war in 1828. A fact, however, is mentioned by M. Tolstoy, lately an officer of the Russian staff, which shows the utter groundlessness of the fears generally entertained of the aggressive powers of Russia at the commencement of the late contest with Turkey. From a variety of data, derived from authentic sources, that officer exhibits the situation and force of the Russian army at different periods of the campaign of 1828, and proves, we think to demonstration, that it never had more than 88,000 men in its first line;[2] a force which was not calculated, certainly, to excite any very great degree of alarm in the minds of other nations. M. Tolstoy, it is true, alleges that political reasons prevented the employment of a greater force; and that if the Russians only brought forward 88,000 men in the first campaign, "c'était qu'ils ne voulaient point effrayer l'Europe et réveiller des jalousies qui sommeillaient." But closer observers will perhaps see reason to believe that the real cause why the campaign was undertaken with a force comparatively so small, did not consist in any particular respect for the "slumbering jealousies" of other nations, but in the inability of Russia to take the field with a larger army; that her physical means are out of all proportion greater than her financial resources or power of developing them in a foreign war; and that, however formidable or invincible she might prove to an enemy invading her own territory, a long period must yet elapse before she can be in a condition to occasion any serious uneasiness to the nations of the south and west of Europe. Even in the campaign of 1829, when so many losses were to be repaired, and the reputation of the Russian arms, if possible, freed from the tarnish they had contracted in the course of the preceding one, Count Diebitsch was compelled to attempt the passage of the Balkan with no more than 30,000 men; and, in point of fact, he appears to have arrived at Adrianople in the month of October, with less than the third of that small force; a miracle of fortune, certainly, but, at the same time, a conclusive proof of the exhausted state of the Russian finances, and of the inability of the czar to carry on a distant and protracted war. Diebitsch owed his success to two causes: the powerful co-operation of the fleet, and the despairing fatalism, or rather infatuation, of the Turks. But the fortunate result of the enterprise cannot blind the world as to the circumstances under which it was undertaken, nor conceal the weakness which preternatural folly, on the part of the Osmanlees, at length gilded with victory.

The Russian *infantry* regiments consist of 3000 men each, under a *pulkovnick* or colonel, and are divided into three battalions of four companies, each under a *chef-de-bataillon*. The company consists of 200 men, exclusive of officers, sub-officers, and other persons attached to it, so that four companies make up a battalion of 1000 men; and it is under the command of a *capitan*, a *parooschick* or lieutenant, a *putparooschick* or sub-lieutenant, and a *praperchick* or ensign. Four officers may appear a small allowance for a company: but, in the first place, Russian soldiers are much more easily managed than our dare-devil fellows, in whose blood the wild spirit of freedom revels so fiercely; and, secondly, the fundamental principle upon which the army of the czar is organized is that of economy in every branch of the service, particularly in the number of officers. Hence, for an effective regular force of 747,000 men, there are no more than 14,224 officers, or one for every 52 men; a proportion, we believe, considerably lower than that which obtains in any other European army, except perhaps that of Prussia. This reduced number, however, has been found to answer well enough in practice; and, indeed, a multitude of officers is only necessary for armies like that of France, which require to be encouraged and stimulated by the example, the voice, and the gestures of its officers, when in presence of an army. Every company has a small green *yaschick* or waggon attached to it, containing sixty rounds of ball cartridge for each man, in addition to those he carries in his pouch, besides the company's books and cash-chest. To each battalion there is attached one standard, beside which is kept a drum for assembling the men. There is only one band for the three battalions composing a regiment. The imperial guard, consisting of the élite of the three arms of infantry, cavalry, and artillery, amounts in all to forty thousand men.[3]

The Russian *regular cavalry* consists of 8 regiments of the guard, 4 of which are cuirassiers and 4 light horse; and 79 regiments of the line, 9 of which are cuirassiers, 17 dragoons, 12 hussars, and 22 hulans. Supposing each regiment, therefore, to consist of 900 men, as stated by Captain Alexander, the total number of the Russian regular cavalry would amount to 78,000. The *irregular cavalry* is composed of more than 20,000 Cossacks, who are only called out during time of war, and on the return of peace are sent back to their steppes to resume their nomadic course of life. All the regiments of the regular cavalry which are not colonized have 6 active squadrons and one in depôt; the colonized regiments, though composed of 12 squadrons, have only 6 disposable. The depôt squadron may be considered the nursery of the regiment to which it belongs. The cavalry is organized upon the same principle as the infantry. It forms, including that of the guard, nine corps d'armée, of 2 divisions each; and as each division consists of 2 brigades, each brigade of 2 regiments, and each regiment of 6 squadrons, every corps d'armée of cavalry consists of 8 regiments or 48 squadrons. Two batteries of horse-artillery are attached to each division, or 48 pieces to a corps d'armée. The light division of the guard is composed of a regiment of dragoons, one of hulans, one of hussars, and one of chasseurs. The division of heavy cavalry of the guard consists of the regiment of chevaliers-guards, of the regiment of horse guards, and of the cuirassiers of the emperor and empress. The two last regiments, as well as the chasseurs

[1] *Etat des Armées Russe et Polonnaise à l'époque de la mort de l'Empereur Alexandre, ou comparaison entre ces deux armées et les autres puissances armées de l'Europe.* Paris, 1826. Mauvillon, *Militär Blätter* for 1826, part 1st. *Bulletin des Scien. Milit.* tom. iii. p. 385.

[2] *Replique à la Réponse de M. Magnier aux Observations d'un officier d'état-major Russe sur la dernière campagne de Turquie*, par J. Tolstoy, ancien officier d'état-major Russe. Paris, Ledoyen, 1829. *Dix chapitres sur la Guerre d'Orient.* Paris, Delaunay et Dupont, 1829.

[3] Captain Alexander's *Travels*, i. 100.

of the light division, belong to the young guard. The guard is recruited in the regiments of the line from which it draws all the finest men, and to which it never fails to send back every one who has given the slightest cause for dissatisfaction. The clothing and equipments are superb; and the greatest attention is paid to the appearance of the troops, which has of late years been much improved. Equitation is also anxiously cultivated, and vast pains have been taken to improve the men in this art. But the system pursued in Russia is considered bad, inasmuch as the ambling pace introduced into the schools is apt to spoil the horses, and to produce any thing rather than bold riders.[1]

The Russian, like the French, *artillery*, is divided into horse and foot. The horse-artillery is divided into brigades or battalions, of two divisions or squadrons, each serving 12 light pieces. The foot artillery is divided into brigades or regiments, each commanded by four superior officers, and divided into two companies of battery, and two light companies. The two former are destined each to serve 12 pieces in battery; the two latter, 12 light pieces each. A brigade of foot-artillery with 48 pieces of cannon is attached to each division of infantry of 6 regiments; while each division of cavalry, composed of 4 regiments, has a brigade of horse-artillery of 24 pieces. There is also in each corps d'armée a general of artillery, who receives the orders of the inspector-general of artillery. The *personnel* of the companies is determined and organized according to the service which the different kinds of artillery require; so that the *personnel* of the battery companies is considerably stronger than that of the light companies. The train is well organized, and the *attelages* of the different batteries and pieces are ample. The *engineer* department is also on a respectable footing, though inferior in science to those of the other great military nations. The Russians have never been remarkable for skill in fortification, but their field-works have in general been judiciously executed.[2]

The system of recruiting in Russia is exceedingly autocratical. When new levies are wanted, orders are issued to the headmen of villages; each of which is required to furnish a certain number, according to the amount of its population. The selection is made by the headman, who is perfectly absolute in the matter; and Jews are now obliged either to serve or to pay for substitutes, who are not easily procured in a country like Russia, where so few of the lower class are their own masters. Formerly, it was very difficult to prevent the men from deserting on the road to the depôts; since the circumstance of being selected as a soldier was considered as tantamount to perpetual banishment from family and friends. Hence, it was no uncommon spectacle to see numbers of these wretched serfs fastened together like a cordon of felons going to the hulks, or tied on telegas or carts, and thus conveyed to the depôt. But since leave has been given to soldiers to visit, at intervals, their native villages, and the period of service has been limited to twenty years, the dislike to the army has begun to abate, and recruits show less disposition to desert, although the military profession is still sufficiently unpopular. When the recruit, or rather conscript, arrives at the depôt, he is immediately stripped, washed, and shaved: if he wishes to retain any article of the dress which he brought with him, he is obliged to purchase it back. The only thing he is allowed to retain, without paying for it, is the cross of silver or brass which he wears round his neck. This, superstition spares him as the only consolation of his miserable existence; and because, however passive in other respects, the most abject serf would become dangerous, if deprived of an emblem which had probably been handed down from father to son for many generations, and the loss of which is considered the greatest misfortune.

The Russian soldier is docile, submissive, and brave: like all slaves, he is supple, subservient, and cunning: like all natives of the northern regions, he is hardy, patient, and enduring. He has no other thought than to do implicitly as he is desired; and there is a pertinacity in his nature which inclines him to persevere, or to stand firm, as the case may be, without troubling himself about consequences. His courage is the result of insensibility rather than of moral force of character; and hence it is commonly more of a passive than of an active character. But there is, nevertheless, an element of indomitable ferocity in his composition: amidst all the apparatus and parade of civilization he is still three parts a barbarian. Hence his most brilliant achievements have been performed under men upon whom the force of civilization had made as little impression as on himself, and whom the instinct of sympathy had taught to develope his natural barbarism. The Italian campaign of Suwaroff affords a striking illustration of this remark. When that "hero, buffoon," arrived in Italy at the head of his 20,000 Russians, to take the command-in-chief of the allied forces, General Chasteler, head of the staff of the army, proposed to him to make a reconnaissance of the French, who had retired behind the Oglio. "Des reconnaissances!" exclaimed the Muscovite chief, "je n'en veux pas; elles ne servent qu'aux gens timides, et pour avertir l'ennemi qu'on arrive; on trouve toujours l'ennemi quand on veut. Des colonnes, la baïonnette, l'arme blanche, attaquer, enfoncer,—voilà mes reconnaissances!" At Novi, at the Trebbia, and during his extraordinary campaign in the mountains of Switzerland, this wonderful barbarian, who had the instinct of genius, and a *coup d'œil* which has never been surpassed, proved that these were not empty words. By a kind of rude but infallible inspiration he discerned intuitively the true strategic points on which to move; and by the spell of his barbaric genius he rendered the Muscovite soldier invincible. Again, in the campaign of 1812, we discover another, though less striking, illustration of this peculiar characteristic of the Russian troops. Barclay de Tolly, a German and a foreigner, commanded in the early part of it; displaying a watchfulness, a prudence, and a sagacity in divining the intentions of his adversary, which proved him a great master in the art of war, and, beyond all question, saved the Russian empire. But still the army was discouraged; and Alexander felt it necessary to place at its head, as well as second in command, two of the ancient companions in arms of the conqueror of Italy. Its courage instantly revived; and the bloody day of Borodino attests how well it repaid this compliance with its wishes. The Russians have a strongly marked national character, which foreigners can never duly appreciate; nor will its best energies be displayed in war, except under the command of men who feel its influence as powerfully as the meanest soldier in its ranks. The moral force of their army consists in a certain nondescript fanatical ferocity, which such men as Suwaroff, Bagration, and Kutusoff can alone fully develope.[3]

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[1] *Bulletin des Scien. Milit.* tom. iv. p. 489 and 529; *Allgemeine Militär Zeitung*, Nos. 17, 18, and 19.

[2] *Ibid.* tom. ii. p. 493; *Zeitsch. für Kriegswissenschaft*, 1826, part 3d, p. 254.

[3] Lieutenant-General Baron Jomini describes the Russian soldier with that predilection in his favour which may not unnaturally be expected from the *aide-de-camp general de S. M. L'Empereur de Russie*, and *grand croix de pleusieurs ordres*. But even while he paints *en beau* that infantry "qui avait prouvé à Pultava, à Kunersdorf, à Choczim, à Ismaël, et dans mille actions contre les Turcs

Army. Swedish army.

In Sweden, union and confidence have always subsisted between the soldier and the citizen; and hence the desire of military service is so common among all classes of the nation, that sending a man to the army is not there, as elsewhere, a punishment. In 1811, when the peasantry broke out in insurrection against the conscription by ballot, they offered to take arms without exception in the event of war, to submit to be drilled together in time of peace, and to equip themselves at their own charge, provided the obnoxious innovation was abolished; tenders which were wisely accepted on the part of the government. The present military establishment of Sweden is considerably below what a nation constitutionally warlike might be supposed to maintain; but as the aim of the government is to husband the public money, and, if possible, to relieve the country from the pecuniary difficulties entailed upon it by the folly and extravagance of the ex-king, all the departments of the public service have been placed on the most economical footing. The actual standing army, accordingly, does not exceed 35,000 men of all arms. The militia, however, is more numerous; and, from the peculiar aptitude of the Swedes for military exercises, it exhibits a very soldier-like appearance, though only trained for a few weeks annually. Like the regular army, it is composed both of horse and foot, and must afford a ready resource in the event of war. The organization of the whole is excellent. The regiments of the line are recruited neither by voluntary enrolment nor by conscription, but by a kind of intermediate system; every landed proprietor furnishing a certain number of soldiers, to each of whom a house and a portion of land are allotted for his maintenance. The Swedes have been long and justly celebrated for their martial qualities; and no modern nation of so small extent has made so conspicuous a figure in history. They are brave, hardy, and naturally heroic men; of superior physical and corresponding moral power; and, as soldiers, equal to any in the world.[1]

Danish army.

The Danish army consists of rather more than 30,000 men, with a reserve of about 14,000. Of this force 2157 are divided throughout the kingdom of Denmark, and 9655 stationed in the duchies; while the remainder are employed in garrison, or occupy cantonments in the vicinity of the capital. The whole is composed of a staff of 23 officers; a corps of engineers of 32; an artillery corps of 3202 men, divided into 22 companies; 6126 cavalry, divided into ten regiments, one of which is a regiment of guards; 13,412 infantry, divided into thirteen regiments of two battalions each, one of which is also a regiment of guards; 2753 chasseurs, divided into five battalions of four companies each; and, lastly, a rocket corps, amounting to 156 men. The two regiments of guards are composed of very fine men, and have a noble appearance. In 1828 the artillery was re-organized, and placed upon a more effective footing, both as to the *matériel* and *personnel*. It now consists of eighteen batteries of eight pieces each; besides a company of sappers and miners, one of pontoon men and pioneers, with a detachment of artificers, and a laboratory establishment. These eighteen batteries are divided into two brigades of nine batteries and 72 guns each. In time of war the battalions of reserve furnish other two brigades, one Danish and the other Holstein; consisting in all of 2640 men, including officers, with a proportional allotment of guns. The Danes are naturally brave, but they have been more distinguished as seamen than as soldiers, in which capacity they have gathered few laurels.[2]

Saxon army.

The electorate of Saxony, with a superficies of 717 square miles, a population of 2,104,336 souls, and a revenue of about 780,000 thalers, maintained in 1792 an army of about 32,000 men, being a 66th part of the population; and on this footing it remained till 1800, when it was increased to 38,000 men, being a 56th part of the population. But Saxony having in 1802 gained a small increase of territory in consequence of the treaty of Luneville, though, at the same time, it lost about 1,778,000 thalers of revenue, the army was reduced to 31,000 men, of which 22,000 were infantry and 6700 cavalry. This state of things continued until 1806, when the military force was raised to 36,000; Saxony having then a population of 2,276,000 souls. In the year 1809 she furnished a contingent to France of 16,000 men, who, under the command of Bernadotte, the present king of Sweden, took part in the memorable campaign of that year, and fought at the battle of Wagram; but the emperor Napoleon was so little satisfied, either with the conduct of these troops, or that of their leader, on this occasion, that he was with difficulty prevented from stigmatising both in the orders of the day. After the peace of Vienna in 1810, the Saxon army was re-organized upon the model of the French, and its contingent of 16,000 men formed the seventh corps of the grand army which invaded Russia in 1812. It was commanded by General Reynier. On the disastrous termination of the Russian campaign, its wrecks, re-organized from the troops remaining in Saxony, entered into line in 1813, after the battle of Lutzen; and on the conclusion of the armistice with the Hessian corps and that of General Durutte, it formed again the seventh division. The defection of the Saxon divisions at Leipsig,

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ou les Suedois, ce qu'on peut attendre de son inébranlable fermeté," he shows his usual discrimination of military character, and makes several observations which appear to us equally striking and original. "L'opinion généralement accreditée en Europe," says he, "que le paysan Russe, ne possédant rien, gagne beaucoup à devenir soldat, est denuée de fondement. Un grand nombre d'entre eux, outre les champs de ses maîtres, cultive des fruits, des légumes, travaille et trafique à son compte. Beaucoup sont à leur aise; et la vie du soldat dans l'interieur du pays, ne leur porte pas envie au point de la désirer. Mais quand ce paysan est sous les drapeaux, il s'y attache comme à une seconde patrie.....Elevé de la manière la plus rude, sous un climat terrible, il est le plus robuste de l'Europe, le plus capable de soutenir les fatigues et les privations. Il ne connaît rien de plus sacré que ses devoirs; soumis à l'ordonnance comme aux précepts de sa réligion, aucune fatigue, aucune intempérie, ne peut lui faire négliger les obligations qu'elle impose. On voit dans toutes les marches et durant une campagne entière, le cannonier près de sa pièce, au poste qui lui est assigné par le réglement, et à moins d'être frappé par le fer ennemi ou autorisé par son chef, il ne la quitterait pour rien au monde. Le soldat du train cire son harnais au bivouac par 15 degrés de froid et au jours fixés, comme il le ferait dans un bon cantonnement pour aller à une parade. Cet esprit admirable d'ordre et de précision, joint à l'instinct naturel que le soldat a de se pelotonner au lieu de fuir quand il est enfoncé, rend les défaites extrêmement rares. Sans doute, une telle troupe est moins facile à rallier sur le terrain qu'une armée Française, où l'intelligence du soldat supplée souvent au défaut d'ordre; mais elle est aussi plus difficile à rompre.....Cet instinct qu'aucune des troupes de l'Europe ne possède au même degré, s'est fortifié chez les Russes par les guerres contre les Turcs. Là, tout fuyard est sabré par les nuées de cavaliers qui se répandent sur les flancs et les derrières de l'armée. Ce n'est qu'en restant fermes et réunies qu'on échappe à une destruction inévitable. This is a tolerably good reason for the "instinct" of which the gallant author speaks. He adds, "La plus parfaite egalité règne dans l'armée, car une fois dans la carrière des armes, aucun obstacle n'empêche de la parcourir. Pour s'en convaincre, on n'a qu'à voir les noms des généraux distingués dans l'histoire militaire de Russie; on y trouvera autant de plébéians, ou de bas-officiers parvenus par leur mérite, que dans tout autre pays." (*Guerres de la Révolution*, tom. i. p. 254–256.)

[1] Alexander's *Travels*, vol. ii. p. 267.

[2] *Bulletin des Scien. Milit.* tom. ii. p. 417. *Nyt Magazin fro Militair Videnskabelighed*, No. 2, p. 323. 1826.

Army.

on the 18th of October 1813, is known to every body. The king of Saxony having lost his liberty in consequence of the result of that disastrous day, his army was dissolved and replaced by a landwehr of from 10,000 to 12,000 men, which followed in the train of the allied armies when they invaded France. In 1815, however, the army was reconstituted to the extent of a third of its former strength; and underwent various changes until 1824, when it was finally placed on the footing on which it now stands. The *infantry* at present consists of two companies of grenadier guards of 100 men each, four regiments of infantry of three battalions each, two battalions of light infantry, one battalion of carabineers and one of chasseurs; in all sixteen battalions, of four companies each, or 9984 men. The *cavalry*, which formerly consisted of horse guards, cuirassiers, hulans, and hussars, has been transformed into four regiments of light horse, consisting of four squadrons of two companies each, or 467 men, on the footing of peace; in all 1872. The *artillery* consists of one regiment making twelve companies, two of which are horse, amounting to 1060 sub-officers and soldiers, together with a train of 189 men and as many horses. A dozen officers without troops, and a company of sappers 67 strong, compose the *engineer* department. The institutions connected with the army are a school for cadets, and a military academy, both at Dresden. The reputation of the Saxon infantry is low; but the cavalry is better than the infantry, and is well qualified for the service of the advanced posts, which was its usual destination under Napoleon.[1]

Hanoverian army.

The composition of the Hanoverian army was fixed by a royal decree of the 14th July 1820. The *infantry* consists of twelve regiments of two battalions each, and the battalion is divided into four companies. There are two of these regiments guards; and the whole are divided into three brigades, the first consisting of five regiments, the second of four, and the third of three. Each regiment consists of 42 officers and 1284 men. There are eight regiments of *cavalry*, two of cuirassiers of the guard, four of hussars, and two of hulans; and each regiment is composed of four squadrons, 48 officers, 433 men, and 403 horses. The *artillery* consists of one regiment of two battalions, each divided into three companies, one of which is horse, and contains 70 officers, 1158 men, and 210 horses. The corps of *engineers* and artificers consists of 19 officers and 46 men. The artillery is of the English model and calibre, and its batteries, both horse and foot, consist of six pieces and a howitzer each. The total strength of the army, therefore, including the staff, amounts to 825 officers, 20,091 men, and 3431 horse. The period of service in the infantry of the guard is four years only, but in all the other corps six years. The cavalry and artillery are recruited as much as possible from volunteers. The Hanoverians make excellent soldiers; and it is well known that, during the Peninsular campaigns, no part of the Duke of Wellington's army more frequently distinguished itself than the King's German Legion, which was almost exclusively composed of Hanoverian volunteers.[2]

Bavarian army.

The Bavarian is one of the largest of the third rate armies. Its *infantry* consists of a regiment of grenadiers of the guard in three battalions, of 16 regiments of the line in two, and of two battalions of chasseurs; presenting an effective force of 37 battalions, or 43,561 men. Its *cavalry* is composed of a regiment of *gardes du corps*, two regiments of cuirassiers in four squadrons each, and six regiments of light horse in six squadrons; forming a total of 48 squadrons, or 9549 men, and 6000 horse. The *artillery corps*, commanded by a lieutenant-general, consists of one regiment of cannoneers of four battalions, one battalion of train in four divisions, and four companies of artificers, pontoneers, sappers, and miners. Each battalion of artillery is divided into six companies, one of which consists of light troops; and the companies of pontoneers, miners, and sappers, have each an effective force of 100 men, including officers. The *engineer corps* is composed of a general, a colonel, a lieutenant-colonel, two majors, two captains, eight lieutenants of the first class, eight of the second, and six conductors, and is divided among the five directions of Munich, Augsburg, Nuremberg, Würtzburg, and Lindau. The Bavarian army, therefore, consists of 43,561 infantry, 9547 cavalry, 3515 artillery, 1464 train, and 150 artificers; in all 56,919 men, with 6420 horse. Every Bavarian, the clergy only excepted, is obliged to bear arms in defence of his country; but, in practice, students and persons necessary to their families are usually exempted; and permission is likewise granted to serve by substitute. The method of recruitment is conscription. Besides the permanent army, there is a reserve destined to reinforce it; and, in the event of war, the landwehr may be equally called upon to support the army, when reinforced by the battalions of the reserve, but only in the interior. The *landwehr* is divided into two classes, one of which comprehends those who are least capable of performing active service, and who cannot in any case be employed beyond the limits of their district. In time of peace it co-operates in the maintenance of public tranquillity, when put in requisition for that purpose, and when the troops of the line are deemed insufficient. The Bavarian army is well organized, and has always maintained a respectable character for discipline and bravery. The cavalry is considered superior to the infantry.[3]

Armies of Wurtemberg and Baden.

The small army of Wurtemberg requires only a brief notice. Its *infantry* consists of 8 regiments of 2 battalions, divided each into 4 companies; its *cavalry*, of a squadron of guards, a squadron of chasseurs, and 4 regiments of horse, each divided into 4 squadrons; its *artillery*, of a regiment of 6 companies, 3 horse and 3 foot, besides a garrison company: but it has no engineer corps distinct from that of the artillery. Its peace establishment is composed of 368 officers, 1504 sub-officers, and 5184 soldiers; or 6996 combatants, and 1806 horse: on a war footing it would amount to 520 officers, 2302 sub-officers, and 14,508 soldiers, or 17,330 combatants, and 5228 horse. The Wurtemberg army is recruited by voluntary enrolment and forced levies. The military age is from 18 to 30 for enrolment, and from 20 to 25 for levies; and, in both cases, the élite of the population only is taken. This little army is well-officered, and enjoys some consideration. Count Bismark, the able author of *Lectures on Cavalry Tactics*, is colonel of the 3d regiment of Wurtemberg horse, and served with distinction as general of brigade in Napoleon's Russian campaign.[4]—The grand duchy of Baden, the seventh state of the Germanic confederation, has a superficies of 279 square miles, with a population of 1,108,000 souls, and supports a military establishment of 12,433 men, although it is only bound to furnish a division of 10,000 men (the 2d of the third corps) as its contingent.[5]

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[1] *Coup d'Œil sur la Force et l'Organisation de l'Armée Saxonne depuis* 1792 *jusqu'en* 1824. Paris, 1825. *Geist der Zeit.* Feb. 1824. *Bulletin des Scien. Milit.* ii. 49.

[2] *Militär Blätter.* vol. i. p. 183. 1821. *Bulletin des Scien. Milit.* ii. 55. 1825.

[3] *Zeitschrift für Kriegswissenschaft*, No. 24, p. 242. *Hof und Staats Handbuch des Königreichs Bayern.* Munich, 1828.

[4] *Bulletin des Scien. Milit.* tom. iv. p. 402. *Königb. Wurtemb. Hof und Staats Handbuch.* Stuttgardt, 1828.

[5] *Allgemeine Militär Zeitung*, No. 10, 1828. *Bulletin des Scien. Milit.* tom. [illegible] p. 65.

Army.

Army of the Germanic confederation.

The organic law of the military constitution of the Germanic confederation, adopted on the 9th April 1821, in the fifteenth full sitting of the diet, and forming the basis on which the federal army has been organized, is exceedingly complex, and altogether unsusceptible of analysis within the space which the limits of this article afford. Its leading provisions, however, may be shortly stated, and are as follow:—The army of the confederation is composed of the contingents of all the states members thereof, raised according to the formation of their particular *matricule* or computation in the diet. The proportion of the different arms is regulated conformably to the principles of the new tactics. The federal army is formed of corps d'armée of a single nation or of combined corps, and both are subdivided into divisions, brigades, and regiments. No state of the confederation, whose contingent forms one or more corps d'armée, can combine contingents of other states with its own in the same division; and the states which have corps or divisions combined, concert together the manner of forming and organizing them, and in case of dispute the diet decides. In the organization of the federal army regard is had to the interest resulting from the particular relations of different states, in as far as can be done consistently with the general object of the confederation; and as the rights and duties of all the confederate states are the same, it is specially provided that every appearance of supremacy on the part of one state over another is to be avoided. The contingent of each state must always be completely equipped and ready to take the field as soon as it shall be called to do so; but the force and assembling of the army to be raised, as well as of the reserve, are regulated by particular dispositions of the diet. 1. The ordinary contingent of each state is one hundredth part of its population, conformably to a table prepared and rectified from time to time by the diet. 2. The proportion of the cavalry of the federal army is fixed at one seventh of the total of the troops; and two field-pieces are required for every 2000 men of the contingent, besides one for every 1000 of the reserve in arsenal. 3. The federal army consists of 10 corps d'armée, 7 simple and 3 combined, designed in the order of the digits or primary numbers; and every corps has at least 2 divisions, each division at least 2 brigades, each brigade at least 2 regiments, each regiment of infantry at least 2 battalions of 800 men each, and each regiment of cavalry at least 4 squadrons of 140 men each. The *minimum* of a contingent of cavalry is 300 horse, of infantry 400 men, and of artillery a battery of six or eight pieces. 4. As the contingent of each state must be ready to take the field in a month after it is called upon, all the *matériel* of armament and provisions necessary for the contingent must be deposited in the arsenals of each state, and all the contingents of the army must be kept up to their full complement even in time of peace. 5. The generalissimo of the confederation is chosen by the diet in ordinary assembly, and his functions cease when the federal army is dissolved. 6. The commanders of the corps of every nation or state have the rights which the sovereign whose troops they command may think proper to confer upon them, without deviating from the principles upon which the military constitution is founded. There is a great number of other dispositions and regulations, touching a variety of matters; but those above specified are the principal, and may serve to convey an idea of the military constitution of this great confederacy, organized in imitation of that which, while it seemed to strengthen the hands of Napoleon, proved eventually, by the defection of its members, one of the chief causes of accelerating his fall.[1]

Army.

Netherlands army.

The military power of the United Provinces dates its commencement from the middle of the fifteenth century, when, after a long and sanguinary struggle, they succeeded in emancipating themselves from the yoke of Spain; and, in the following century it received considerable development in consequence of the wars which they had to maintain against Louis XIV. In 1702 they had in their pay upwards of 100,000 men, exclusive of 30,000 who were in the service of the Dutch East India Company. But this period may be regarded as the highest condition of the army of Holland, which subsequently declined both in number and reputation; so that in 1775 it did not exceed 30,000 men, fully one third of whom were foreigners. In 1789, Holland, with a population of 2,340,000 souls, inhabiting a country of 625 square miles, supported an army of 36,000 men, consisting of 40 regiments of infantry and 10 of cavalry; and with this force it joined the first coalition against the French republic. In 1792 the Dutch army had been increased to 39,000 infantry, 3450 cavalry, 1560 artillery, and 260 miners and pontoneers; making a total of 44,270 combatants. But in the campaigns of 1793 and 1794 they afforded the Prince of Orange occasion for displaying considerable military talents, put his army to a decisive test, and impressed all with a conviction that its degeneracy in moral force was equalled only by the radical defects of its organization. The conquest of Holland by the French, however, was followed, in 1795, by the reorganization of the army on new bases; and so great was the effect of the changes thus introduced, that the Batavian troops, led by Dumonceau and Daendels, rivalled the French, by whose side they fought, both in discipline and valour, and at Alkmaër, on the Rednitz, and on the Danube, bravely upheld the ancient reputation of the Dutch arms. At the peace of 1815, Belgium having been united to Holland in order to form a constitutional monarchy, and England having restored the greater part of the Dutch colonies which had fallen into its hands during the republican and imperial regime, the new kingdom of the Netherlands at once, and as it were *per saltum*, took its place among states of the second order, with a continental superficies of 1165 square miles, and a population of 6,166,854; and lost no time in organizing a military system suited to its position and rank among the nations of Europe. This system rests on a permanent army of about 50,000 men on the footing of peace, and 82,000 on that of war; with an eventual army of national guards estimated at 40,000 during peace, and 124,000 on a war establishment. The kingdom is divided into 6 great and 17 provincial commands, 6 directions of artillery and engineers, and 50 cantons for the levy of the militia and the organization of the national guard. The great commands are confided to lieutenant-generals, the provincial commands to major-generals, the directions of artillery and engineers to general officers, and the militia cantons to old officers of a superior grade. The *infantry* consists of 18 divisions of 4 battalions from 3 to 6 companies each, with a depôt company; the *cavalry*, of 9 regiments 4 squadrons each, of which 4 are cuirassiers, 2 light dragoons, 2 hussars, and 1 lancers; the *artillery*, of 10 battalions, 4 of the line and 6 of the militia, each of 6 companies, a corps of light artillery, and a battalion of the train; and the *engineers*, of a battalion of miners, sappers, and pontoneers. There is also included in the army a colonial depôt, to which are attached 2 correctional divisions, 5 garrison companies one of them artillery, and 9 companies of *maréchaussée*, stationed in the southern provinces of the kingdom. The army of the Netherlands is recruited exclusively from the natives of the country, first, by voluntary enrolments;

[1] *Bulletin des Sciences Milit.* tom. ii. p. 45. *Loi Organique de la Constitution Militaire de la Confédération Germanique*, 1821.

Army.

secondly, by engagements and re-engagements for two, four, and six years, with a bounty; thirdly, by calling out the whole or part of the militia; and, lastly, by the recal of men absent on leave, or by having recourse to the reserve. The militia is composed of youth between the ages of 19 and 23, and draughts are made every year in the month of March, in the presence of the commissaries of militia and the local authorities. Advancement is principally regulated by seniority; but every soldier distinguished for intelligence and good conduct may aspire to the rank of officer. The army of the Netherlands has still a character to make for itself. As a national force it has never as yet been put to the test. But it has been organized with great care, and unless political dissensions interfere to destroy its *morale*, there can be little doubt that it will conduct itself respectably when called to serve in the field. The Belgian troops, it is true, behaved ill at Waterloo; but they were evidently disaffected to the cause for which they were called to fight.[1]

Sardinian and Neapolitan armies.

The kingdom of Sardinia, containing a superficies of 1363 square miles, and a population of 4,334,000 souls,[2] supports an army of about 31,000 men on its peace establishment, and 62,000 during war, exclusive of militia. The permanent army consists of the household troops, the royal guard, the troops of the line, and the carabineers. The household troops consist of four companies of horse-guards, called the Savoyard, the Piedmontese, the Sardinian, and the Genoese. The royal guard is composed of a brigade of grenadiers, and a regiment of chasseurs *à pied*, of the same composition and force as a regiment of the line. The *infantry* of the line consists of 9 brigades of 2 battalions each in time of peace, and 4 during war; the *cavalry*, of one regiment of dragoons, two of light horse, and one of the line, each consisting of 8 squadrons or 4 divisions. The carabineers amount to 3100 men, including officers and 100 élèves, and form a sort of nursery for the army. Since the 3d January 1823, the corps of *artillery* has consisted of 4 battalions, of which 2 are of the line, 1 light artillery, and 1 partly garrison artillery and partly artillery of the train. The royal corps of *engineers* is composed of a supreme council, a staff, a company of miners, and some sappers. At the beginning of the French revolution, the Sardinian army amounted to 30,000 infantry, 3600 cavalry, and upwards of 2000 artillery and engineers. In the year 1815, its total force, exclusive of the royal guard, was not less than 70,000 men. "La Piémontais," says Jomini, "est un excellent soldat; la service des régimens provinciaux a familiarisé toute la nation avec les armes; la peuple, comme la plupart des habitans des montagnes, est frugal, endurci à la fatigue, et brave."[3] But the cavalry is much inferior to the infantry; for the horses are bad, and the men ill adapted by habit and character to this branch of the service.[4]—The Neapolitan army is scarcely deserving of notice, either in a political or military point of view; for, next to the soldiers of his Holiness the Pope, those of Naples are beyond all dispute the worst in Europe. In 1792 the Neapolitan army amounted to 30,000 troops of the line, as they were called, and 15,000 militia; a force which was increased, in 1799, to 60,000 men of all arms; 40,000 of whom invaded the Roman states during the campaign of that year, and conducted themselves rather like banditti than a regular army. Formidable only to its allies, and to the country which it serves to retain in abject servitude, this army has since experienced the most violent mutations; but its number at present may be estimated at from 35,000 to 40,000 men of all arms.

Ottoman army.

At the period when the Ottomans first became formidable to Europe, they may be said to have composed one immense army. Every Osmanlee was a soldier, and from the age of sixteen to sixty held himself at the disposal of the state; whilst all were animated with a martial fanaticism, which in fact constituted the main sinew of their strength. They were brave, ardent, enterprising; and if their services in the common cause (which they could not withhold as long as they were able to bear arms) remained unpaid, they were not unrequited. A third of the conquered land was distributed amongst them, and held on the tenure of military service; the peasantry cultivated the fields thus ceded to the soldiery, and paid the rents to their military landlords; and the holders of the *ziamets* and *timars*, or greater and lesser grants, received from the fund of conquest rewards proportioned to their services. But this system, although it placed a large numerical force at the disposal of the chief, was nevertheless attended with serious inconveniences. It created a sort of feudal militia, but was incompatible with the existence of a permanent force; it supplied means for a short expedition or campaign, but a continued series of operations was constantly liable to be paralyzed by the soldiers returning to their homes while these were still in progress. To obviate this evil, it was resolved to raise a body of mercenaries, whose services should be at all times available. Accordingly, sultan Amurath, at the suggestion of his vizier, claimed as his right the fifth part of the Christian youth captured in Bulgaria, Albania, Servia, and Bosnia; who, being instructed in the law of the prophet, and inured to arms, formed a body of soldiers totally distinct from those liable to serve in virtue of their military holdings, and unconnected with the rest of the empire by the ties either of birth or of kindred. Such was the origin of the janissaries. Organized into a regular force, at a time when the armies of Christian powers consisted of a disorderly militia, and uniting courage and enthusiasm with a species of discipline, and a blind obedience to the will of their commanders, this powerful body swept all before them, and spread far and wide the terror of the Ottoman arms. Nor did the splendour

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[1] *Notice sur l'Armée Néerlandaise:* Extrait d'un ouvrage inédit de MM. Urbain et Geehender, capitaines Néerlandais. *Bulletin de Sciences Milit.* tom. viii. p. 1, 81. The above account of the Netherlands army was written before the revolutionary convulsions in Belgium had effected the separation of that country from Holland; but we allow it to remain unaltered, because, finding it impossible to tell what now *is*, we have judged it best to leave the reader to infer what may be from that which has recently been, and to form an estimate for himself of the military force of each of these countries separately, from that which was either organized or capable of being brought into the field under their federative union.

[2] On the continent Sardinia has only 918 square miles of territory, and 3,839,000 souls. The *terra firma* of this kingdom, situated between Switzerland, France, and Italy, forms, on the side of the last-mentioned country, a great basin, which the principal chain of the Alps separates from Savoy, the department of the Isère, and the county of Nice. It may be considered a vast entrenched camp, having, on the side of France, Savoy and the county of Nice as advanced posts. In fact, these transalpine provinces have a free communication with each other only by the plain of Piedmont, where the debouchés from Savoy are by the Great and Little St Bernard, and from the county of Nice by the Col di Tende and the route of La Corniche. This position, which constitutes the king of Sardinia the natural guardian, or porter of the Alps, as he has been called, causes his alliance to be eagerly sought for both by France and by Austria, particularly the latter, who, conscious that her hold of Italy is by no means firm, has an interest in raising up every obstacle to prevent France, in the event of a war, from attacking her on her weakest side.

[3] *Guerres de la Révolution*, tom. i. p. 244.

[4] *Etat Militaire de la Sardaigne depuis la Restauration en* 1814. Paris, 1824. *Zeitschr. für Kunst, Wiss. und Gesch. des Krieges*, No. 5, p. 197. *Bulletin des Scien. Milit.* tom. ii. p. 1, and tom. viii. p. 297.

of their achievements suffer any eclipse as long as Christian captives could be obtained to fill the vacancies in their ranks. But when the janissaries ceased to form a class distinct from the great mass of the nation; when they were allowed to marry and enrol their children; and when the *odas* or regiments became encumbered with men who preferred inglorious ease in the bosom of their families to the toils and dangers of the battle-field; they at the same time ceased to be formidable to their enemies, and, like the prætorian cohorts of ancient Rome, were dreaded only by their emperors. They could raise an insurrection in the capital, demand the head of an obnoxious vizier, and depose or murder an unpopular sultan; but "the yellow-haired Giaours" had learned to despise them in the field; and, in their degeneracy, they seemed destined to accelerate the ruin of that empire which, in their better days, they had contributed so largely to extend and consolidate.

On this class of men, however, did the Porte, until recently, depend in a great measure for defence against her enemies; and although their inefficiency was daily becoming more apparent, and reform more necessary, every attempt to effect a change of system, and regenerate these Osmanlee prætorians, had proved either abortive or disastrous. In vain did Selim try to remodel them, and restore discipline. The attempt cost him his life. In vain did Mahmoud, on his accession, manifest an intention to enforce the regulations of Suleiman the Magnificent. An insurrection was the consequence. During three days the streets of the capital ran with blood; and the sultan, in order to save his own life, was obliged to command the execution of his brother. But Mahmoud was not of a disposition to be daunted by this failure, although it induced him to change his mode of proceeding. He now saw that nothing less than the complete destruction of the janissaries would enable him to improve the condition of his empire, by carrying through the reforms which he already meditated; and he waited patiently until he could strike the blow with a certainty of success. In 1826, the janissaries, who perceived the storm gathering, again mutinied. But it was now too late. They found the sultan prepared for them; and, in raising the cry of insurrection, they only gave the signal for their own destruction. The artillery-men and other troops, faithful to Mahmoud, surrounded them in the Etmeidan: they attempted to defend themselves, but without success: 20,000 perished in the conflict: and the janissaries as a body were from that moment annihilated. This achievement, though accomplished at a terrible sacrifice of life, was in reality an act of humanity as well as of sound policy; and, viewed in its proper light, it reflects equal honour on the wisdom and firmness of the sultan, who planned so judiciously and executed so vigorously a measure full of peril in itself, yet absolutely indispensable as a preliminary step to improvement of any kind.

The suppression of the corps of janissaries having left Mahmoud at liberty to remodel his army conformably to the principles of European science and tactics, he hastened to supply the void occasioned by the destruction of the force to which the country had hitherto trusted for its defence; and orders were immediately issued directing the enrolment of a certain number of men in every province of the empire, excepting Albania, Bosnia, and the African states. But the sultan experienced greater difficulty in raising new troops than he had probably anticipated; for, although the law which places the services of every Moslemin at the disposal of the sultan existed in full force, it applied only to a state of war; and on no previous occasion had such a system of enrolment been resorted to during time of peace; a circumstance which rendered it exceedingly obnoxious to the populace. Another obstacle to the speedy reconstruction of the army consisted in the necessity of excluding from the new corps all persons suspected of what may be called *janissarism;* and as it had been customary for every Moslemin, on attaining the age of manhood, to inscribe his name in some oda or regiment of janissaries, the only method by which Mahmoud could hope to secure his troops from the contamination of that proscribed sect was by enrolling none but boys in his army. But the adoption of such a plan necessarily created a proportionate difficulty in filling the ranks; while, to add to the embarrassments of the Ottoman reformer, the new system had scarcely been twelve months in operation when Russia declared war against the Porte. That this was a politic proceeding on the part of the Muscovite government, no one can doubt. Mahmoud was caught in the very act of transition from a bad system to a better one; the regiments of the Ottoman army were still incomplete; and the unpopularity of the contest, with a dread of the Russian arms, acted as an additional check to enlistment, and thus aggravated the evils with which the sultan had to contend. The new troops were, however, brought into action. They were as yet too ignorant of the advantages of discipline to benefit by the instructions they had received; their manœuvres served but to confuse them; the officers were superior to the men only in name, and the generals were equally destitute of talent; the interior organization of the army was lamentably defective; and the troops had but little confidence either in their officers or in themselves. Yet, with all these disadvantages, the first campaign terminated favourably for the Turks; and it cannot reasonably be doubted that the second one (that of 1829), would have had a similar result, if the Osmanlees had been commanded by a man possessed even of ordinary military talents and enterprise. The grand vizier was unquestionably a brave man; and, unlike Yusuff Pasha, he was faithful as well as brave. But, with 40,000 regular troops, superior to any that the Porte had ever sent into the field, he allowed himself to be surprised at Kiulewtscha or Kuleftscha, and, having lost more than the half of his force, was compelled to retire to Shumla with the remainder. The succeeding events of the campaign were the natural corollaries of this disastrous battle: But without dwelling upon these, which are foreign to the objects of the present article, we shall proceed to give some account of the Ottoman army as it is at present constituted.[1]

The Ottoman army is composed of regular and irregular infantry and cavalry, a corps of artillery, and a regiment of bombardiers or miners. The *Assakiri Mansurei Mohamediyes*,[2] or regular infantry, are said to amount to 50,000 men, of whom 10,000 compose the imperial guard, quartered in and around Constantinople. They are recruited from the mass of the people without distinction; and although Mahmoud did not oblige the children of his nobility to enter into the service, yet, at the beginning of the late war, many enlisted voluntarily, and even some of the Ulemas, or expounders of the law, forsook their peaceful profession and enrolled themselves. The black and white

[1] Trant's *Narrative of a Journey through Greece* in 1830, p. 364, *et seqq.* We take this opportunity of acknowledging our obligations to Captain Trant's work for a very considerable portion of the details respecting Sultan Mahmoud's military reforms, as well as the present condition and strength of the Ottoman army. There are many points, in regard to which it could have been wished that Captain Trant had been somewhat more specific; but on a subject where exact information was not easily attainable, military men ought to be grateful for what this respectable officer has been able to collect concerning it.

[2] Literally, "victorious troops of Mohammed."

subjects of the sultan are alike received as soldiers; and, in a single regiment, may be seen every shade of "the human face divine," from the jet-black complexion of the Ethiopian or Nubian to the white-visaged inhabitant of Rumelia.[1] Once enrolled, a soldier is obliged to serve for life; but it frequently happens that discharges are granted. The regular troops are organized on the model of the French army, and are divided into corps d'armée, divisions, brigades, and regiments. The corps d'armée is commanded by a seraskier, the division by a pasha of three tails, the brigade by a pasha of two tails, the regiment by a miri-alaÿ or colonel, and the battalion by a bimbashee or chef de bataillon. A regiment consists of a regimental staff (including the miri-alaÿ or colonel, the caimacan miri-alaÿ or lieutenant-colonel, and the alaÿ-eminy or major) and three battalions, each composed of one bimbashee or chef de bataillon, one sagh-col-aghassy or adjutant-major, one sol-col-aghassy or adjutant, 8 yuzbashees or captains, 16 mulazims or lieutenants, 32 tchiaouchies or serjeants, 48 on-bashees or corporals, and 720 men; making a total of 2484 officers and soldiers, exclusive of a drum-major, an imaum or chaplain, and a kiatip or clerk. The inveterate prejudices of the Moslemins against the employment of European officers in the service have prevented Mahmoud from placing any foreigners in command of his troops; and these have hitherto been disciplined, partly by officers who had served under Selim in the Nizam Djedid, partly by persons sent from the Egyptian army. The only footing on which the Turks will consent to tolerate an European officer is as an instructor; and in this capacity Signor Calosso, a ci-devant captain of dragoons in the Italian army of prince Eugene Beauharnois, has been employed by the sultan to superintend the discipline of his cavalry. But the infantry have not been equally fortunate, and are consequently labouring under very great disadvantages. The officers, taken from the same class of society with the common soldiers, differ from them in nothing but rank and name: in the Turkish army there is no one to look up to, no natural aristocracy created by superiority of condition and of knowledge: the same ignorance and the same prejudices pervade all ranks: and, having the benefit neither of examples nor of models, their progress in discipline has been necessarily slow. The Turks seem to think that performing the manual and platoon exercises with tolerable precision, marching in companies instead of independently, and wearing a peculiar uniform, is sufficient to class them with disciplined troops. But, in their anxiety to attain the end desired, they have overlooked some of the most essential means. The soldier, for example, is placed in the ranks before he knows how to march; and provided he goes through the manual and platoon exercises, it matters not whether his carriage be steady or the reverse. When in the ranks, the men talk and laugh without restraint, and even address themselves to their officers; whilst the latter, instead of checking, encourage these improprieties, by joining in or retorting the rude ribaldry of the troops. Field-officers are indeed treated with the most obsequious respect by their inferiors; but the line which has been drawn betwixt the privates and subaltern officers is by no means sufficiently distinct; and it is easy to perceive throughout, that the hand of a master is wanting to combine all the elements of discipline, which are now but imperfectly understood, and to impress upon the higher ranks the necessity of studying their profession, in order to qualify them for discharging the duties of command, as well as to ensure the respect and obedience of the troops.

The Turkish *cavalry* had so long been celebrated for its gallantry and enterprise, that the policy of remodelling it seems exceedingly questionable. This, however, has been attempted, though, as it appears, with very indifferent success. Four squadrons of dragoons are attached to the guard, and compose the only regular cavalry in the empire. These are mounted and equipped in the European fashion; but the horses are small in size, ill-conditioned, and badly groomed;[2] and the men find so great difficulty in accommodating themselves to the European method of riding with long stirrups, that their seat is loose and ungraceful, and they are not unfrequently thrown from their saddles, to their own infinite mortification. The scimitar, so effective in the hand of a Turk when mounted in the fashion of his country, has also been exchanged for the French light dragoon sabre; a weapon so differently balanced from that which the Osmanlees have long been accustomed to handle, that they are not likely soon to acquire much dexterity in the use of it. These changes, in fact, seem the very wantonness of innovation; for whilst they have destroyed all that is national or characteristic in this description of force, they have substituted nothing effective in its stead; and Mahmoud will probably find to his cost that he has sacrificed a superb light cavalry for wretched dragoons. His policy should have been, to leave to the Turks their national horsemanship and their national weapons, and to direct his attention exclusively to field tactics and manœuvres, in order to give unity and effect to those daring charges which they are so admirably fitted to execute effectively in their own way. Without firmness in their saddles or confidence in their weapons, the new troops may make a tolerable appearance on parade; but if sent into the field, they will, in all probability, be found unable to contend with the worst description of horse to which they may be opposed.

The *artillery* is of two kinds, viz. foot and horse. The topejees or foot artillery are said to be at present 6500 strong; and although their new organization has not taken place, it is understood to be the intention of the sultan to form them as soon as possible into regiments. The horse-artillery, though in a very inefficient state compared with ours, has made considerable progress in discipline. It is divided into two regiments of four troops each; and every troop consists of one captain, three subalterns, 180 men, 180 horse, and 10 guns; thus making the total effective strength of a regiment 786 men, 720 horses, and 40 guns, which are commonly nine-pounders and five-and-a-half-inch howitzers. The officers are supplied with horses by the government; and the forage allowed to each horse is nine pounds of barley and twelve pounds of chopped straw *per diem*. The corps of bombardiers and miners amounts to about 2000 men; but they are still quite undisciplined, and as ignorant of the scientific as they are negligent of the practical part of their profession; their gun carriages, platforms, and ammunition waggons, being in a shameful state, and totally unfit for service. The education of artillery officers has hitherto been entirely neglected; but a college has recently been established for their instruction in the theory and practice of gunnery.

The irregular army may be said to comprise the whole

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[1] "Ah!" said a janissary to Captain Trant, while observing a body of troops marching past, "what kind of soldiers are these? You see every race and every colour on earth amongst them!" Granted; but martial qualities are not necessarily connected with colour; and discipline, if rigorously enforced, will in time mould even these variegated elements into a fine and formidable army.

[2] This may seem singular, considering the ideas generally entertained of Turkish horses: but, in the first place, these are very much exaggerated; and, secondly, the government were obliged to purchase horses wherever they could be found—in Asia, Rumelia, and Wallachia. The best horses belong to the irregular cavalry.

Mahommedan population of the Ottoman empire; since, as already stated, every Moslemin, if required, is obliged to join the army during time of war. The irregular cavalry is raised by the Znaims and Timariots, who hold feudal grants from the Porte on tenure of military service. The irregular infantry is assembled by the pashas and inferior officers in the provinces. Sixty years ago, the irregular cavalry constituted by far the most formidable and effective force belonging to Turkey; but the country whence it was derived having been wrested from the Porte by Catherine II., her enemies now use it with great effect against her.[1] The Khans of the Crimea were most useful tributaries of the Porte, and were at all times ready to take the field with from 40,000 to 50,000 horse of the very best description, considered as irregular troops. Brave, hardy, accustomed to support fatigue and privation, inured to riding from their infancy, and obedient to their leaders, the Crim Tartars formed the main strength of the Turkish armies; and, superior to the Timariots, who had become enervated by peaceful habits, were prepared for all kinds of service, nay even to encounter the best regular cavalry that could be brought against them. The loss of the Crimea, therefore, and of the enterprising troops it supplied, inflicted a severe, if not an irreparable, injury on the military resources of Turkey. The irregular cavalry is now principally drawn from the Asiatic provinces; but as the Mahommedan population has much decreased, this force is consequently less numerous than formerly. The irregular infantry, called Seimens, is furnished by the pashas, ayans, mousselims, and voivodes; and, during the last war, some regiments so raised received pay from the Porte. The men were drawn from Rumelia and Asia; and it is not a little remarkable, that of those who distinguished themselves most in the field, the majority had belonged to the proscribed corps of janissaries, many of whom are still to be met with in all parts of the empire, notwithstanding the severe measures adopted for their extermination. The spirit of janissarism, indeed, is still latent in a large portion of the population. The sultan has scotched the snake, not killed it; and the utmost vigilance will be necessary on his part to prevent its resuscitation.

The military establishments of Turkey have yet, in a great measure, to be created; but the sultan is indefatigable in urging on improvement to the utmost extent of his crippled means. The only founderies for casting cannon are in Constantinople. They are three in number: one of two furnaces, attached to the military arsenal at Tophana; another, also of two furnaces, near the naval arsenal; and a third of one furnace at Hassquiou, the bombardier barracks. In one of these establishments sufficient metal can be melted to cast from five to seven guns at a time; but in all, the tools are of the coarsest description, and every thing is effected by manual labour, without the aid of machinery. The workmen are Turks and Armenians. The military arsenal at Tophana contains a large stock of artillery of various calibres, and some of extraordinary length.[2] The field-pieces are in tolerable order, but the guns have neither sights nor scales. A manufactory of muskets has existed for some years; but although as many as 120 can be made daily, the supply is found insufficient, and the troops are mostly armed with French muskets purchased at Marseilles. There are eight handsome barracks in and near Constantinople, viz. Daoud Pasha, Ramah Chiflic, the Seraskiers, Tophana, Scutari, Hassquiou, and the two Pera barracks, which have been erected either by Selim or Mahmoud, and are said to be capable of containing 72,000 men, although this is most probably an exaggeration. They are by far the most splendid edifices in Constantinople, and are considered equal to any structures of the kind in Europe. Schools or colleges of medicine, of the marine, of music, and of military instruction, have been recently established at Constantinople. The medical school contains about 100 students, and the number will probably be soon increased, as each regiment is to have both a physician and surgeon attached to it.[3] Between three and four hundred young men are instructed at the military school, which is under the superintendence of the chief bombardier, in mathematics and the principles of fortification and gunnery; and some few French works upon military subjects have been translated into Turkish for the benefit of the students. Sultan Mahmoud has also established a kind of commissariat department, under the control of the Asker Nazirÿ, or superintendent of the troops; but the establishment is yet in its infancy, and the arrangements are very imperfect. Greater progress has, however, been made in reforming the pay department, in which enormous abuses formerly prevailed; the troops and the sultan having been alike plundered by the knaves intrusted with this important branch of the public service. But since the management of the finance, commissariat, and general organization of the army has been vested in the Asker Nazirÿ, conjointly with the seraskier and other high official persons, matters have been placed on a much better footing, and the soldiers have now little to complain of. The new military code has been modelled upon that issued by Sultan Suleiman, when he reformed the corps of janissaries, and restored their ancient discipline; and although it is still in many respects imperfect and defective, it seems, upon the whole, calculated to ameliorate the moral condition of the Ottoman soldier.

Greek army.

The reforms effected by Sultan Mahmoud in the military organization of the Turks rendered it expedient for the Greeks to attempt to form regular corps, in order to keep on a level with their enemy in point of discipline and tactics. Accordingly, on the 27th February 1827, the president ordered a military force to be organized in regiments (*chiliarchies*) of two battalions (*pentacosiarchies*), divided into five companies (*hecatoncharchies*) each; a regiment to con-

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[1] During the last campaign the Turks had generally bad information, frequently none at all, respecting the movements of the Russians; whilst clouds of Cossacks scoured the country in every direction, cut off the Ottoman *éclaireurs*, explored all the routes and even bye-paths, and conveyed to head-quarters prompt intelligence of the slightest movement on the part of the enemy. It was this entire command of the communications which gave Diebitsch so great a superiority during the latter part of the campaign, and enabled him to surprise the vizier at Kiulewtscha, to mask the celebrated march by which he turned the barrier of the Hæmus, and to acquire for himself the well-merited distinction of Zabalkansky, or Passer of the Balkan. The troops sent to intercept him in the mountain gorges arrived too late, and Zabalkansky was thus enabled, with a handful of troops, to dictate peace in the ancient capital of the empire.

[2] Near the seraglio are several enormous guns carrying stone balls like those fired at our fleet when passing the Dardanelles in 1808. But cannon of this description can only be discharged with effect when the object passes their line of fire, as they are not mounted upon carriages, but built in a wall. Some of the guns at the Dardanelles carry balls twenty-six inches and a half in diameter.

[3] There was nothing in Turkey which stood more in need of reform than the healing or rather the killing art. With all their predestinarian prejudices, the Osmanlees place unbounded faith in the skill and knowledge of physicians; and although they have been at all times ready to acknowledge the superiority of Europeans in the science of medicine, they have nevertheless for the most part been obliged to intrust the welfare of their bodies to empirical adventurers, whose knowledge had been acquired much in the same manner as that of the learned hakim Yacoob, so admirably described in "Anastasius." Mahmoud's medical school, if it prosper, may in time have the effect of putting down those pernicious quacks.

Army.

sist of a colonel (*chiliarch*), two chefs de bataillon (*pentacosiarchs*), 10 captains (*hecatontarchs*), 20 lieutenants (*pentacontarchs*), 40 sub-lieutenants (*eikosi-pentarchs*), 80 serjeants (*dodecarchs*), 160 corporals (*pentarchs*), and 800 soldiers; in all 1122 men. Another decree of the 17th October ordains the formation of a battalion of artillery of six companies, with a suitable cortège of officers; and embodies in it a sort of provisional code of military law. But little or no progress has as yet been made in the organization of a standing force; for the battle of Navarin and the war between Russia and Turkey removed the immediate stimulus of fear, which alone can make the Greeks carry through any thing; whilst the favourable turn which affairs have since taken, and the certain establishment of Greek independence, have rendered the measure in some degree unnecessary. We may add, that the decrees are drawn up in a very crude manner, and make no mention whatsoever of the number of chiliarchies or regiments which it was intended to raise.[1]

American armies.

The American armies require only a very cursory notice. That of the United States, exclusive of militia, does not amount to 10,000 men. It consists of seven regiments of infantry, four of artillery, some engineers, and a sort of general staff; and it is formed into three divisions, each under the command of a general officer. That called the eastern, under the orders of major-general Gaines, is composed of 53 companies, consisting of 233 officers, and 2662 non-commissioned officers and privates. The western division, commanded by Brigadier-General Atkinson, is also composed of 53 companies, amounting in all to 2463 men, including 178 officers. The third division, which has no relative territorial denomination, consists solely of recruits enlisted for the regular service in different parts of the union, and does not exceed 2500 men. The republicans of the west have a great aversion to a standing army, and only maintain a sort of skeleton, to be filled up, in case of need, from the militia force. The troops of the United States excel in bush-fighting; but they have neither organization nor discipline, and on any other soil than their own would be any thing but formidable.[2]—The Mexican army is considerable. A few years ago it consisted of 3 brigades of artillery, 12 battalions of infantry, 13 regiments of cavalry, 31 garrison companies, and 12 fixed companies of infantry and cavalry; making a total of 22,750 men: besides a militia of 42,017 men, of whom 21,577 were in active service. At the period referred to, therefore, the whole armed force of Mexico amounted to 64,697 men, of whom 44,327 were then in active service. Menaced with invasion by the mother country, and torn by contending factions, this new state cannot at present have fewer men under arms than at the time when the returns were made from which this brief notice has been drawn up.[3]—The black army of Hayti consists of the president's guard, with the infantry and artillery of the line. The guard, which ranks at the head of the army, consists of two regiments of infantry, one grenadiers and the other chasseurs, and three regiments of cavalry, one of carabineers, one of grenadiers, and one of chasseurs. There are 33 regiments of infantry of two battalions each, and every battalion has six companies, viz. one of grenadiers 80 strong, one of chasseurs 50, and four of fusileers 44 men each. Attached to this infantry, and distinct from the guard, are two regiments of dragoons of two squadrons, divided into two companies of 70 men each. The artillery consists of five regiments of two battalions, divided into nine companies of 50 men each, including officers. There is also an engineer corps, with 26 companies of 50 men each of artificers and pioneers. The whole of the Haytian force, therefore, including the staff and the president's guard, amounts to about 26,000 or 27,000 men.[4]—We are not in possession of any accurate details respecting the composition and force of the various South American armies. The Brazilian is estimated at from 35,000 to 40,000 men, including militia; the Colombian or Venezuelan at from 15,000 to 20,000; the Peruvian at 20,000; and the Chilian at from 10,000 to 12,000 men of all arms. But these numbers are in a great measure conjectural. The military force of the Argentine republic is probably not greater than that of Chili or Venezuela; while that of Paraguay amounts to about 5000 regulars and 20,000 militia.[5]

British army.

From time immemorial the inhabitants of the British Islands have been distinguished for a determined bravery, united with a degree of physical power, which belongs to the people of no other nation; and hence, as soldiers, they have never yet, when properly commanded, found their match in the field of battle. "L'Angleterre," says Count Turpin, in his commentaries on Montecuculi's *Mémoires*, "est elle peut-être la nation où la bravoure se soutient depuis le plus long temps." "Our nation," observes Dr Johnson, "may boast, beyond any other people in the world, of a kind of epidemic bravery, diffused equally through all its ranks; we can show a peasantry of heroes, and fill our armies with clowns whose courage may vie with that of the general." The valour of a Briton is innate. It is a national instinct, co-existent with and inseparable from the man himself, and requiring no artificial excitement to bring it into action; and it is as powerful at the present moment as it was in the chivalrous days of Cressy, Poictiers, and Agincourt. Hence, although the fortune of our arms may have varied, the character of the soldier has always remained the same; and at Waterloo as at Blenheim, and Ramilies, and Malplaquet, he established his superiority in all those high military qualities which render a nation invincible. But, from various causes, the reputation of the British army, which the campaigns of Marlborough had raised to the highest pitch, and which the various actions of the Seven Years War had gloriously sustained, began subsequently to decline; while the disastrous results of American revolutionary war created an opinion, which succeeding events appeared to confirm, of its total unfitness for prosecuting a lengthened series of operations, or contending with any prospect of success against the armies of other nations, particularly those of the Continent. It was conceived to be little better than a body of marines, well qualified to co-operate with the navy in partial expeditions, or in making descents on the seacoasts of any country with which Great Britain happened to be at war, but incapable of maintaining itself in the field, or of engaging in regular campaigns; and, to say the truth, there were not wanting plausible reasons which might be alleged in support of such an opinion. For, as if they had been determined, not merely to countenance this impression, but really to render the army as inefficient and as utterly destitute of consistence and energy

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[1] Abeille Greque, 18th September 1828.

[2] Documents accompanying the President's Message to Congress at the commencement of the first Session of the 19th Congress. Washington, 1825. General Report on the Army of the United States, extracted from documents communicated to Congress, Niles' *Register*, January 1830.

[3] *Memoria del Secretario de Estado y del Despacho de la Guerra.* Mexico, 1826. *Bulletin des Sciences Milit.* tom. iii. p. 386.

[4] *Almanach National pour* 1827. *Bulletin des Scien. Milit.* tom. v. p. 473.

[5] *Essai Historique sur la Révolution du Paraguay*, par MM. Rengger et Lonchamp. Paris, 1827.

as it was generally believed to be, the British ministry persisted for a series of years in wasting its strength in paltry expeditions, or in effecting partial descents upon this or that country, instead of combining one great effort calculated to influence the general result of the contest. Yet, in 1795, the regular army, including the force under the Duke of York in North Holland, exhibited a total of 119,000 men, besides about 42,000 employed in the colonies, in Corsica, in Gibraltar, and in Portugal; a force which, directed with skill and judgment, might have saved the country from many humiliations, prevented an enormous accumulation of debt, and accelerated the termination of a sanguinary and ruinous contest, from the effects of which the nation is still suffering. The campaign of Egypt, in 1801, showed, it is true, some small degree of energy, and, above all, afforded the army an opportunity of proving its undiminished excellence. But, unfortunately, on the renewal of the war in 1803, the old system was resorted to, and all the prejudices which had previously existed against the army were revived with tenfold force;—prejudices which outlasted the first successes of the Peninsular campaigns, and which were only at length overcome by an unexampled series of victories, obtained over the ablest generals and the best troops of which France could boast.

"The French army," says Colonel Napier, "was undoubtedly very formidable from numbers, discipline, skill, and bravery; but, contrary to the general opinion, the British army was inferior to it in none of these points save the first, and in discipline it was superior, because a national army will always bear a sterner code than a mixed force will suffer. With the latter the military, not the moral crimes, can be punished; men will submit to death for a breach of great regulations which they know by experience to be useful, but the constant restraints of petty though unwholesome rules they will escape from by desertion, or resist by mutiny, when the ties of custom and country are removed; for the disgrace of bad conduct attaches not to them, but to the nation under whose colours they serve. Great, indeed, is that genius that can keep men of different nations firm to their colours, and preserve a rigid discipline at the same time. Napoleon's military system was, from this cause, inferior to the British, which, if it be purely administered, combines the solidity of the Germans with the rapidity of the French, excluding the mechanical dulness of the one, and the dangerous vivacity of the other; yet, before the campaign in the Peninsula had proved its excellence in every branch of war, the English army was absurdly underrated in foreign countries, and absolutely despised in its own. It was reasonable to suppose that it did not possess that facility of moving in large bodies which long practice had given to the French; but the individual soldier was (and is still) most falsely stigmatised as deficient in intelligence and activity, the officers ridiculed, and the idea that a British could cope with a French army, even for a single campaign, considered chimerical. The English are a people very subject to receive and to cherish false impressions. Proud of their credulity, as if it were a virtue, the majority will adopt any fallacy, and cling to it with a tenacity proportioned to its grossness. Thus an ignorant contempt for the British soldiery had been long entertained before the ill success of the expeditions in 1794 and 1799 appeared to justify the general prejudice. The true cause of those failures was not traced, and the excellent discipline afterwards introduced and perfected by the Duke of York was despised. England, both at home and abroad, was, in 1808, scorned as a military power, when she possessed, without a frontier to swallow up large armies in expensive fortresses, at least two hundred thousand[1] of the best equipped and best disciplined soldiers in the universe, together with an immense recruiting establishment, and, through the medium of the militia, the power of drawing upon the population without limit. It is true, that of this number many were necessarily employed in the defence of the colonies; but enough remained to compose a disposable force greater than that with which Napoleon won the battle of Austerlitz, and double that with which he conquered Italy. In all the materials of war, the superior ingenuity and skill of the English mechanics were visible; and that intellectual power that distinguishes Great Britain amongst the nations, in science, arts, and literature, was not wanting to her generals in the hour of danger."[2]

It is almost needless to add how conspicuously this brave and unequalled army disproved the calumnious prognostications of its contemners and revilers; how gloriously it established, in seven campaigns and more than twenty pitched battles, its superiority over the veterans of France, crowned with the laurels of a hundred victories, and accounted invincible till called to contend with the men of our soil. Let us now direct our attention to its composition and organization.

By the constitution of this country the king is the supreme head and captain-general of the army, which can receive no orders except such as emanate from him, and is bound to obey all his orders, unless at variance with the fundamental laws of the land; in which case submission to his authority would be declared rebellion against the constitution of the state, and the nation at large. To him belongs the power of declaring war and concluding peace, of granting subsidies to his allies and indemnities to his enemies: but no treaty is valid or binding unless it be signed by a responsible minister; and without the authority of parliament he cannot touch a sixpence of his subjects' money for this or any other purpose. Further, it is expressly declared in the bill of rights, and annually repeated in the preamble to the mutiny-act, which forms the martial law of the British army, "that the raising or keeping a standing army in time of peace, unless it be with the consent of parliament, *is against law*;" in other words, no military force can be raised or maintained in this country, except with the consent of the three estates composing the legislature, by which, in their collective capacity, the sovereign power of the state is exercised. But in regard to the existing army, all measures and all acts deemed necessary for its regulation, direction, and employment, are decided upon by the king in council; and it is the duty of the commander-in-chief of the forces for the time being to direct the execution of such measures or acts, in all those operations which are executed within the united kingdom, as well as to superintend the organization, instruction, and discipline of the troops belonging to the different branches of the service.

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[1] At the period in question the British army consisted of 30,000 cavalry, 6000 foot-guards, 170,000 infantry of the line, and 14,000 artillery; in all 220,000 men. Of these between 50,000 and 60,000 were employed in the colonies and in India; but the remainder were disposable, because from 80,000 to 100,000 militia, differing from the regular troops in nothing but the name, were sufficient for the home duties. If to this force we add 30,000 marines, the military power of Great Britain, at the time referred to, must have exceeded 400,000 men, exclusive of local militia and volunteers.

[2] *History of the War in the Peninsula and in the South of France, from the year* 1807 *to the year* 1814. By W. F. P. Napier, C. B. Lieutenant-Colonel, H. P., 43d regiment, vol. i. p. 10 and 11.

The secretary at war is, by the terms of his commission or appointment, bound to give effect to the orders of the commander-in-chief, issued with the approbation and consent of the sovereign; excepting in as far as these shall appear to be contrary to the rules of the service, or to make any alteration in the expenditure of the army: in which cases it is his duty to make reference to the lords of the treasury, and to act in strict conformity to their instructions. This minister, in fact, who is not a member of the cabinet, is specially charged with the administration of the war department in all its branches. He is the organ of communication between government and the army on the one hand, and between the army and the government on the other; and he acts as a check upon the commander-in-chief, while he is in his turn restrained by his responsibility to parliament, to the country, and to the laws.

The departments exclusively military are those of the adjutant-general, the quarter-master general, the barrack-master-general, the commissary-general, the paymaster-general, and the board of ordnance.

The adjutant-general's department consists of the adjutant-general himself, the deputy-adjutant-general, the assistant-adjutant-general, and the deputy-assistant-adjutant-general, with ten or eleven clerks, three messengers, and a keeper. The adjutant-general belongs to the personal staff of the king, and accompanies his majesty and the commander-in-chief in all their reviews and military inspections. He is named directly by the king, on the recommendation of the commander-in-chief, and has the rank of lieutenant-general, though for the most part only a major-general. The deputy-adjutant-general is also appointed by his majesty; but the secondary offices of the department are filled by persons nominated by the adjutant-general himself. This officer may be considered as the director of the *personnel* of the British army. Every thing relating to the effective or non-effective state of the troops; to formation, instruction, and discipline; to the direction and inspection of the clothing and accoutrements of the army; to recruitment, leaves of absence, or bounties to soldiers; to the employment of officers of the staff; and to ordinary or extraordinary and official returns relative to these different matters, whether required by his majesty, by the ministry, by the secretary at war, or by parliament; falls within the province of the department over which the adjutant-general presides. He is the regular channel through which commanders of corps communicate with the commander-in-chief; and all orders, special instructions, and general regulations issued by the commander-in-chief, relative to the organization, discipline, or instruction of the army, are prepared, addressed to the commanders of corps, and published by the adjutant-general, conformably to the direction of the commander-in-chief of the forces, acting in the name and on behalf of his majesty. The troops stationed in Scotland, however, instead of communicating directly with the adjutant-general's office in London, address themselves to the deputy-adjutant-general who resides at Edinburgh; and Ireland has an adjutant-general of its own. It is also the duty of the adjutant-general to prepare, weekly, for the commander-in-chief and the king, returns of the troops stationed in Great Britain and Ireland; and, monthly, for the commander-in-chief, the ministers, and the king, a general statement of all the forces both at home and abroad.[1]

The quarter-master-general holds the same rank, and is appointed in the same manner, as the adjutant-general. His principal duties are to prescribe routes and marches, to regulate the embarkation and disembarkation of troops, to provide quarters for them, to mark out ground proper for encampment, to execute military surveys, and to prepare plans and arrange dispositions for the defence of a territory, whether such defence is to be operated by the troops alone or by means of field-works. Every British army on service has a quarter-master-general, with deputies and assistants, who perform functions altogether analogous to those which are discharged in the department of quarter-master-general of the British forces; and it is admitted on all hands that, during the Peninsular campaigns, this branch of service was, under the very able direction of Sir George Murray, carried to a high degree of perfection. Whenever the army, established for the time in any position whatever, had to move in advance and in a given direction, all the officers of the quarter-master-general's staff, charged with the reconnaissances, immediately set out and spread themselves over the ground, each individual taking the direction indicated to him, and pushing his reconnaissance to the extent of a day's march of the army. About five in the afternoon these officers returned to head-quarters; and by combining their different partial sketches, a general plan was prepared, according to which the quarter-master-general and the commander-in-chief traced the routes to be followed, and the positions to be taken up, by the troops who were to march on the morrow. This was the duty of every day while the army was in motion; and no better evidence can be produced of the ability with which it was performed, than the circumstance that, during the whole of the Peninsular campaigns, the army never once took up a position in which it could be assailed by the enemy, however superior in numbers, with the remotest chance of success. Attached to the office of quarter-master-general of the forces is a board of topography, with a depôt of maps, plans, and military memoirs, and a library containing the best military works that have been published in different countries.[2]

The barrack-master-general's department is a numerous one, consisting of ninety functionaries in London, and eight in Edinburgh, exclusive of barrack-masters, store-keepers, hospital-store-keepers, barrack-sergeants, and clerks. His principal duty is to provide barracks, permanent as well as temporary, for the reception of the troops; to superintend their construction or repair; and, generally, to take care that the troops are properly accommodated, both as to room and otherwise. Subordinate to him, of course, are all the local barrack-masters, whose duty it is to furnish bedding and other necessaries for the troops in their respective barracks. Ever since 1805, Great Britain has had 84 barracks built of stones or bricks, 12 constructed of timber, 75 temporary barracks, and 48 hired for rent, in all 212; which, it is calculated, are sufficient for affording accommodation to 100,000 infantry and 15,000 cavalry.

The commissariat department, when complete, consists of a commissary-general, a deputy-commissary-general, an assistant-commissary-general, and a deputy-assistant-commissary-general, with upwards of two hundred subordinate functionaries. The head of the department is the commissary-general, who resides in London, and directs the whole of this branch of the service, whether at home or abroad. Subordinate to the treasury in as far as regards financial matters, he is at the same time under the control and direction of the war-office in reference to military operations. His duties, which have been greatly increased since the report of the special committee of finance in the year 1797, consist in supplying provisions, forage, and camp as well as barrack equipage, to the troops;

[1] Dupin, *Force Militaire de la Grande Bretagne*, l. ii. p. 54.

[2] *Ibid.* l. ii. p. 59.

in providing the materials of the medical department of the service; and, generally, in directing and superintending all those furnishings which usually enter into the army extraordinaries of the year, of which he prepares a monthly account for the treasury, and an annual return to be laid before parliament. Three months after the close of every year, he also lays before the auditors of public accounts a financial statement of the receipts and disbursements of the preceding year; before the comptrollers of the army, a general view of the receipt, deliverance, and consumption of supplies furnished by his department; and before the lords of the treasury, a detailed account of the various items of expenditure, of the pay and half-pay of persons attached to the commissariat, as well as of the expense of field-works and signals. All the furnishings of provisions, forage, &c. made to the troops stationed in Great Britain are supplied by army contractors; but, for other articles, the commissariat finds it more advantageous to pass a contract at the moment of need, and for the quantity required, than to enter into any permanent engagement beforehand for the supply of particular articles. The accounts of the contractors, after being compared with the regimental receipts, as certified by the commanders of corps, are then transmitted to the war-office to be again compared, by the superintendent of army accounts, with the effective force and distribution of the different corps, as well as with the regimental returns; and the concordance of these different verifications serves in the first instance as a guarantee to the ministry. The commissary-general has neither the custody nor the delivery of any supplies or materials whatever; nor does he keep any account of disbursements made out of Great Britain.[1] Every army in active service has its own commissariat, under the orders of a commissary-general, who is responsible, in the first instance, to the general-in-chief, for the regular supply of the troops under his command. In Portugal and in Spain, the provisioning of the army was effected by all the means to which recourse could be had in countries so poor and exhausted; but the greater part of the necessary supplies was obtained by purchases effected by commissaries stationed at different places or attached to brigades, and paid from funds supplied by the commissary-general of the army, consisting partly in cash, and partly in bills or debentures on the English government. Immense abuses appeared to have prevailed in the commissariat department during the early part of the peninsular campaigns. This is evident from the repeated orders of the day issued by the Duke of Wellington against malversations on the part of subordinates in this department; and not less so from the fact that, notwithstanding all the care and vigilance exercised by his Grace, many of these functionaries managed to realise fortunes.[2]

The paymaster-general is the head of the army pay-office, whence the issues for the payment of every description of military service are made. This office consists of the paymaster-general himself, two deputies, an accountant-general, a cashier, book-keepers, clerks, and other subordinates; and there are several deputy-paymasters abroad subordinate to the general department at home. The paymaster-general has no active control over the expenditure of the public money. His duty is merely to make payments ministerially and without discretion, in pursuance of the warrants directed to him by the secretary at war, the treasury, or both, as the case may be; or in honour of the drafts of the deputy-paymasters abroad, for the ordinary services of the army. The pay-office must therefore be looked upon as an office of account merely, and as affecting the public expenditure only in as far as it performs the duties of an office of accounts with regularity and expedition. The materials and documents, which compose a considerable part of the account of the paymaster-general, originate with persons over whose conduct he exercises no manner of control. Indeed there is a regular succession in preparing them, from the regimental paymaster to the agent, and from the agent to the secretary at war, who finally delivers them at the pay-office. Different classes of accounts and documents are delivered in at certain periods prescribed by the pay-office act. But large balances of the public money are not now, as formerly, allowed to remain in the hands of the paymaster-general, or at his credit in the bank; nor can he derive any profit from the custody of the public money, the balances being confined within the narrowest possible limits. The establishment of a regiment, with the king's regulations and warrants, is in fact the instrument which regulates the pay of the army, and is consequently the basis of all the documents which enter or go out of the pay-office under that head of the service.[3] Other details are foreign to the immediate object of this sketch, which is merely to give a brief outline of the constitution and functions of those departments immediately connected with the army.

The ordnance department, which comprehends the artillery and engineers, is administered and commanded by a master-general, assisted by a council or board, composed of the lieutenant-general of the ordnance,[4] who in the absence of the master-general directs the military part; of the inspector-general, who, with his agents, has the control of the munitions and stores, as well as of the accounts; of the commissary, who has the direction of the accounts both in money and materials, and who prepares every month for the treasury, and every year for parliament, the ordnance estimates; of the principal storekeeper, who is responsible for the existence and conservation of the whole *matériel;* and of the clerk of deliveries, who has the superintendence of whatever goes out of the magazines. The written orders of the master-general are of course executary in all the branches of this department; but he commonly intrusts to the board the administration of the *matériel* and of the expenditure. In case of absence or vacancy, and when the master-general does not of himself exercise any part of his authority, the board in like manner officiates in his stead. The ordnance has a special paymaster or treasurer, who advances the funds necessary for the department, on orders or drafts, signed by at least three members of the council. Almost all the officers of the board are at the same time members of the House of Commons.

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[1] Dupin, *Force Milit. de la Grande Bretagne*, l. iv. c. iii. p. 149. James's *Military Dictionary*, *voce* Commissary-General.

[2] La trésorerie (says M. Dupin) faisait toutes les avances de fonds à l'armée d'Espagne sur les estimations anticipées du commissaire-général, vues et approuvées par le général en chef, et par lui transmises (comme *duplicatum*) au sécrétaire d'état de la guerre et des colonies. Ensuite le commissariat payait moitié en espèce, moitié en obligations du gouvernement Anglais." (*Voyages dans la Grande Bretagne*, prém. part. Force Militaire, p. 153.) From the ignorance of the Spaniards, however, or rather perhaps from their experience of the faithlessness of their own government, these "obligations" or bills became speedily depreciated to the extent of 26 or 30 per cent., and were purchased from the peasantry and farmers at this discount by the commissaries, who, of course, realized an enormous profit on these transactions. At one period of the Peninsular war the depreciation exceeded 50 per cent.; but the avidity of the commissaries to purchase the debentures increased the confidence of the people in their validity, and thus reduced the depreciation to the amount above stated.

[3] James's *Military Dictionary*, *voce* Pay-office.

[4] This office it is now proposed to abolish.

Army.

The sums voted for the support of this department proceed upon estimates of the ordinary and extraordinary service, and of services unprovided for. The ordinary service comprehends the provision for the ordinary establishment, civil and military, for the year ensuing; the extraordinary includes every service known beforehand, of a temporary and contingent nature, during the currency of the year; and the services unprovided for consist of services which have either been actually paid for in the course of the past year, or which are supposed to have been paid, but which were not foreseen when the estimates of the preceding year were prepared. Among these unforeseen expenses are included various exceedings which may have occurred in the individual services voted in the ordnance estimates of the previous year; to which are commonly added such sums as may be considered necessary to make up the deficiency of the sum allotted to the ordnance for the use of the naval service. So much for the military departments.[1] Let us now attend to the composition of the army itself.

The British army consists at present of 8818 cavalry and 95,786 infantry; but of this force 2804 cavalry and 17,312 infantry are employed in the East India Company's territories; leaving an available force provided for in the estimates of the year 1830 of 6014 cavalry and 78,474 infantry, or 89,284 men of all arms, including officers. This force is divided into cavalry, infantry, artillery, engineers, and some corps immediately connected with the two latter branches of the service, as the royal artificers, the artillery-drivers, and the royal waggon train.[2]

The *cavalry* on home service consists of the first and second regiments of life-guards, and the royal regiment of horse-guards (blue), each of 344 rank and file and 274 horses, with nineteen other regiments of dragoon-guards and dragoons; namely, seven of dragoon-guards, three of dragoons, and nine of light-dragoons, including lancers and hussars, amounting to 5897 rank and file, with 4892 horses; or, including the regiments of life-guards, 6919 rank and file, and 5714 horses. In this enumeration, however, the cavalry serving in India, the waggon-train, and the Cape corps of mounted riflemen, are not included. The first regiment of dragoon-guards consists at present of 407 rank and file, and 307 horses; but the remaining regiments of the cavalry of the line have only 305 rank and file and 253 horses each. The officers and non-commissioned officers of a regiment of life-guards, on its present establishment, amount to 89; of a regiment of the cavalry of the line, to between 60 and 70.[3] Thus, supposing the latter to consist of 368 privates, divided into 8 companies or squadrons, such a regiment would have 1 colonel, 2 lieutenant-colonels, 2 majors, 8 captains, 8 lieutenants, 8 cornets, 1 paymaster, 1 adjutant, 1 quarter-master, 1 surgeon, 1 assistant-surgeon, and 1 veterinary-surgeon, or 35 officers in all; besides 28 sergeants and 8 trumpeters; making a total of 71 officers and non-commissioned officers, and raising the entire strength of the regiment to 439 men. And the same relative proportion obtains, whatever be the footing in point of effective force, on which the regiment is placed.

Since the peace of 1815, various changes have been made in the arms and equipments of our cavalry. In the first place, armour was given to the life-guards, immediately after they had proved its total inefficiency in the field of battle, and torn the laurels of Waterloo from the redoubted cuirassiers of France. That armour must prove a decided impediment to the efficiency of a dragoon on service, is what no one can for a moment doubt. Its enormous weight,[4] the constant cleaning which it requires, the pain which its inflexibility must occasion under fatigue, and the obstacles it opposes to the free and full action of the muscular powers of the human body, greatly detract from its advantages. These, moreover, have been overrated; and we are much mistaken if it will not one day be shown that the life-guards, encumbered with the cuirasses, are immeasurably less formidable than they were when their natural strength, weight, and activity, had full freedom of action allowed them. In the next place, four of our regiments of light horse have been converted into lancers. We agree in opinion with Montecuculi that the lance "est la reine des armes pour la cavalerie;" and we also think, with Major Beamish, that lancers should constitute the standard cavalry of England. But we do not the less object to the particular kind of lance introduced into our service, and the description of cavalry to whom it has been assigned. No nation possesses such materials as Britain for the formation of redoubtable lancers; no nation has the command of such means of bringing them to perfection: and if solid squares of infantry are ever to be penetrated by cavalry, it must be performed by cavalry armed with the lance. But this will never be achieved by such a weapon as that at present in use. It must be effected by a lance of sufficient length to overcome the infantry bayonet, which, thus opposed, would no longer be formidable; and this lance must be put into the hands of our heavy cavalry, particularly the household troops, which, thus armed, would be able to contend on equal terms with the best infantry in the world, and would unquestionably be capable of penetrating its closest formation.

The British *infantry* on home service is composed of 3 regiments of guards, viz. the 1st or grenadier regiment, the Coldstream regiment, and the 3d regiment, amounting together to 5104 rank and file; of 79 regiments of the line, consisting of 1 battalion each, 740 strong; of one regiment (the 60th foot) and the rifle brigade, two battalions each; of 2 West India regiments, the royal waggon train, 2 companies of the royal staff corps, 3 Newfoundland and 3 royal veteran companies, the African corps, the Ceylon regiment, and the Cape corps of mounted riflemen; making a total of 66,240 men, exclusive of the guards. The regiments of infantry of the line have only one battalion as a constant nucleus. When additional battalions are raised, they are employed separately, and commanded each by a lieutenant-colonel. With regard to the colonelcy of a regiment, it is in a great measure a sinecure. The ordinary staff of a battalion of 800 men, rank and file, consists of 1 lieutenant-colonel, 2 majors, 10 captains, 12 lieutenants, 8 ensigns, 1 paymaster, 1 adjutant, 1 quarter-master, and 1 surgeon with 2 assistants; in all 39 officers. The petty staff is composed of a sergeant-major, a quarter-master sergeant, a paymaster sergeant, an arm sergeant, a schoolmaster sergeant, 10 colour sergeants, 30 sergeants, a drum-major, and 21 drummers; in all 106 men. Hence the total strength of such a battalion would consist of 39 officers, 106 non-commissioned officers, 40 corporals, and 760 soldiers, or 906 men in all.[5]

The force at present serving in India consists of 4 regiments of light dragoons, each 701 strong, or 2804 in all;

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[1] Dupin, l. v. c. 1, p. 175.

[2] Estimates of Army Services for the year 1830 (Parliamentary paper).

[3] Army Estimates for 1830.

[4] The largest sized cuirass worn by the life-guards weighs 15 pounds; the smallest 12 pounds 6 ounces. A life-guardsman, in marching order, weighs upwards of 25 stone, supposing the man personally to weigh 13 stone! Besides, these cuirasses are as ugly as they are weighty, and give to the really fine men who are compelled to wear them an appearance of being *hump-backed*.

[5] Army Estimates for 1830.

and 21 battalions of infantry, each 740 strong, or, including supernumeraries and others, 17,312 in all.

The *royal artillery* forms only one corps, which is absurdly denominated a regiment, since, in time of war, it is increased to more than 24,000 men. The master-general of the ordnance has the title and powers of colonel of the regiment of artillery; the lieutenant-general of the ordnance is lieutenant-colonel; and a general officer, with the title of deputy-adjutant-general, performs the functions of head of the artillery-staff, but is in no way dependent upon the adjutant-general of the British forces. The board of the deputy-adjutant-general of artillery is at Woolwich, which may be considered the head-quarters of the ordnance. The royal artillery corps consists of the brigade of horse-artillery, and of the artillery serving on foot. The horse-artillery is subdivided into companies called troops, varying in number from six to ten. Of these two served in the Peninsula in 1808, five in 1813, and seven at Waterloo in 1815. It is under the orders of 2 colonels commanding, 2 colonels *en second*, 2 lieutenant-colonels, and 1 major; while each company or troop is commanded by a captain of the first rank, a captain of the second, and 3 lieutenants. The foot artillery is divided into battalions of ten companies each, under the orders of 2 colonels, first and second, 2 lieutenant-colonels, 1 major, 1 adjutant, 1 quarter-master, and a surgeon with 2 assistants in time of war, and 1 during peace. In the year 1792, there were 4 battalions of foot artillery of 820 men each, with one of invalids containing 483; making 3707 in all. In 1814, there were 16,157 artillery-men, forming 11 battalions of 1459 men each. In 1819 there were only 9 battalions of 8 companies and 638 men each, or 5742 in all; which is pretty nearly the actual strength of this arm. The rocket corps is attached to and forms part of the artillery; and the same thing holds of the royal artificers, the royal waggon train, and the artillery drivers.[1]

In the war which preceded the peace of Amiens, and even in the early campaigns in Portugal, the *engineer* department was in a very ineffective condition; particularly from the want of the necessary means of transport, and partly also from a deficiency both in the number and quality of military artificers. In order to remedy these inconveniences, the Duke of Wellington, in 1814, caused a brigade of engineers, consisting of a company of sappers and miners, with horses, cars, and drivers, to be attached to each division of the army, and to be regularly trained and exercised in field duties, as well as in those which might be required of them in sieges. A captain and a certain number of subalterns were specially attached to each brigade, and were held responsible for the effective condition both of the men and the horses. Thus the remainder of the engineers, free from any embarrassments relative to the *matériel* and *personnel* of that department of the service, were enabled to give their undivided attention to important military operations, and to contribute, in a most essential manner, towards the success of the succeeding campaigns. Five companies of sappers and miners also served with the pontoon-train, which consisted of eighty pontoons, besides forges, waggons, &c. drawn by about 800 horses; the whole under the orders of a major of the brigade of engineers. Since the peace great attention has been paid both to the instruction and organization of this important branch of the service; which, in the event of another war, will be found on a very different footing, in point of efficiency, from that on which it stood during the greater part of the Peninsular campaigns. Experience taught important lessons, which have been suitably and effectually improved.

The portion of the British army presently serving in India amounts, as we have already seen, to about 20,000 men. The European troops in the company's service consist of 8000 infantry and 4000 artillery; while the native regular troops are, according to the best information, composed of 10,000 cavalry, 130,000 infantry, and 8000 artillery; and the native irregular force, of 7000 cavalry and 17,000 infantry. Our Indian army, therefore, may be considered as amounting to 19,000 cavalry, 168,000 infantry, and 12,000 artillery, or, in all, about 200,000 men. The organization of the native army being, in all essential respects, the same as that of the British army, no particular description of it seems to be required under this head.[2]

The character of the British army has been earned in battle and attested by victory. Wherever it has been even tolerably led, it has conquered; nor is there any army in the world which has sustained so few serious reverses. The elements of which it is composed are such as, if fairly developed in action, must, on any thing like equal terms, insure victory: for not only are the soldiers more robust, and possessed of greater physical power (or, as it is technically called, *bottom*), than those of any other nation, but they are also distinguished by an unflinching, indomitable courage, which may be safely reckoned upon at all times and in all circumstances; which it is often difficult to restrain, but never necessary to excite; and which always rises to a pitch of sublime elevation at the prospect of the charge and the close combat. They are the only troops in the world who look with indifference on naked points, and who are constantly impelled by a powerful instinct to close with their enemy; who maintain the distant battle with unyielding stedfastness, yet rejoice when the moment arrives that is to rest the issue of the conflict on the bayonet's point, and a struggle hand to hand with the enemy. Hence their fire is close, steady, and destructive; their charge, where it can be given, irresistible. "Les troupes Anglaises," says General Jomini, "se distinguent par leur bonne discipline et leur sang-froid; le soldat s'y enrôle pour la vie [this is a mistake; soldiers may enlist for any period], ce qui est bien extraordinaire chez un peuple si jaloux de sa liberté, mais ce qui ne surprend pas moins, c'est qu'il est docile et soumis: ces qualités essentielles qui constituent une armée solide, sont peut-être préférables à une valeur brillante mais passagère. Les unes sont permanentes; l'autre, justifiant le proverbe Espagnol, dépend de tel jour et de telle circonstance. La résignation et la discipline unies au courage froid, ont des résultats invariables et sûrs; elles produisent l'ensemble sans lequel il n'est point de véritable force.[3] M. Dupin, in that part of his able work in which he treats of the military force of Great Britain, delivers an opinion somewhat similar to that expressed by Jomini, though shaded by certain qualifications and abatements.

"Il faut de dire," says he, "après les Français, tels qu'ils ont été pendant vinq-quatre ans dans nos armées, les Anglais sont les militaires les plus actifs de tout l'Europe; ils le sont d'une manière qui leur est propre. Leur activité n'a pas les élans prodigieux dont nous avons tant fois offert de mémorables exemples; mais elle n'a jamais d'intermittence, et se montre toujours la même. Cela lui fait produire, au bout d'un temps donné, une somme de résultats plus grande qu'on n'aurait pu le prévoir, d'après la vue d'une action

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[1] Dupin, *Force Milit. de la Grande Bretagne*, l. v. c. 4, p. 196.
[2] Dupin; Army Estimates for 1830; and *Bulletin des Sciences Militaires*.
[3] Jomini, *Guerres de la Révolution*, tom. ii. p. 252.

isolée même la plus brillante. Le soldat Bréton a généralement moins d'esprit naturel et de pénétration que le soldat Français; mais l'immobilité de son imagination rend ses actions plus mesurées. Moins distrait par la vue des objets extérieurs, par les souvenirs du passé, par les espérances ou les terreurs de l'avenir, il est toujours tout entier au moment présent. Plus attentif au commandement actuel, il compense ainsi *l'infériorité de son intelligence.* Incapable de juger les grands mouvemens qui s'exécutent, et surtout ceux qui vont s'exécuter, pour ou contre lui, le danger futur ne se peint pas même à sa pensée. Il va donc à la mort *présente* sans s'inquieter de la mort *à venir.* Voilà pourquoi le moral de l'armée Britannique est presque impossible à détruire par la mauvaise fortune."[1]

In this passage there is some truth, mixed up with much nonsense and misrepresentation. The British soldier, it seems, is inferior to the French soldier in intelligence. And why? Because he does not concern himself about "grand movements executed and to be executed;" and because he is more attentive to command, and goes to *present* death without disturbing himself about *death to come.* These appear strange grounds upon which to rest the alleged superiority of the French or the inferiority of the British soldier in point of intelligence. That a native of this country, admitted on all hands to be at least one of the most intellectual on the face of the earth, should be at once metamorphosed by a red coat into a mere automaton or lump of living but impassible matter, would indeed be an extraordinary phenomenon; nor must it appear less singular that the French armies, with all their intellectual superiority, and all their attention to "grand movements," should have been constantly overthrown by our animated machines. But the plain fact is, that the assertion is wholly erroneous. The English soldier is inferior to no other that ever existed in point of intelligence; and even the late General Foy, whose book appears to have been written chiefly for the purpose of calumniating our army, makes admissions which show that such was his own real opinion, while maintaining a contrary one. This officer repeatedly says that the non-commissioned officers of the British army are superior in activity, intelligence, and zeal to those of the same rank in any other army, not excepting the French; and that this superiority was conspicuously evinced throughout the whole of the Peninsular campaigns. But these persons are taken almost indiscriminately from the ranks, and of course must represent the average amount of intelligence and activity diffused amongst the private soldiers; a circumstance which General Foy had not adverted to when he made the admission in question; for he was too good a Frenchman to allow British soldiers any merit which he could decently and with any show of probability deny them.

But the best answer to all his captious and querulous strictures is to be found in his own description of the conduct of the British regiments at Waterloo. "The cavalry which supported them," says he, "was cut to pieces [this is not true], the fire of their artillery completely silenced. The general and staff officers were galloping from one square to another, not knowing where to find shelter. Carriages, wounded men, parks of reserve, and auxiliary troops, were all flying in disorder towards Brussels. Death was before them, and in their ranks; disgrace in their rear. In this terrible situation, neither the bullets of the imperial guard, discharged almost point-blank, nor the victorious cavalry of France, could make the least impression on the immovable British infantry. One might have been almost tempted to fancy that it had rooted itself in the ground, but for the majestic movement which its battalions commenced some minutes after sunset, at the moment when the approach of the Prussian army apprised Wellington that—thanks to numbers, thanks to the force of inert resistance, and as a reward for having contrived to draw up brave fellows in battle—he had just achieved the most decisive victory of our age."[2] The British army can desire no better panegyric than this, pronounced by a beaten enemy; and if the French shall continue to comfort themselves with the idea that the British soldier is deficient in intelligence, because he possesses that strength of mind which no danger can appal, and that tenacity which carries off the prey by sticking to it to the last, it would certainly be a pity to deprive them of any slender consolation which they may derive from cherishing such a delusion. But instead of adding any thing further of our own, we shall conclude by citing an authority which, on this as on all other military subjects, is universally admitted to be of the highest order.

"That the British infantry soldier," says Colonel Napier, "is more robust than the soldier of any other nation, can scarcely be doubted by those who, in 1815, observed his powerful frame, distinguished amidst the united armies of Europe; and, notwithstanding his habitual excess in drinking, he sustains fatigue, and wet, and the extremes of cold and heat, with incredible vigour. When completely disciplined, and three years are required to accomplish this, his port is lofty, and his movements free: the whole world cannot produce a nobler specimen of military bearing; nor is the mind unworthy of the outward man. He does not indeed possess that presumptuous vivacity which would lead him to dictate to his commanders, or even to censure real errors, although he may perceive them; but he is observant, and quick to comprehend his orders, full of resources under difficulties, calm and resolute in danger, and more than usually obedient and careful of his officers in moments of imminent peril.

"It has been asserted that his undeniable firmness in battle is the result of a phlegmatic constitution, uninspired by moral feeling. Never was a more stupid calumny uttered. Napoleon's troops fought in bright fields, where every helmet caught some beams of glory; but the British soldier conquered under the cold shade of aristocracy: no honours awaited his daring, no despatch gave his name to the applauses of his countrymen; his life of danger was uncheered by hope, his death unnoticed. Did his heart sink therefore? Did he not endure with surprising fortitude the sorest of ills, sustain the most terrible assaults in battle unmoved, and, with incredible energy, overthrow every opponent; at all times proving that, while no physical military qualification was wanting, the fount of honour was also full and fresh within him?

"The result of a hundred battles, and the united testimony of impartial writers, of different nations, have given the first place amongst the European infantry to the British; but, in a comparison between the troops of France and England, it would be unjust not to admit that the cavalry of the former stands higher in the estimation of the world."[3] (A.)

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[1] Dupin, vol. ii. l. 1, c. 1, p. 3, 4.

[2] Foy, *History of the Peninsular War*, vol. i. p. 224, English translation.

[3] *History of the War in the Peninsula and in the South of France*, vol. iii. p. 271, 272. London, 1831.

ARNALL, William, a political writer, who was employed by Sir Robert Walpole to write the *Free Briton* in defence of his administration, for which, by the report of the secret committee, he is said to have received L.10,997. 6s. 8d. He died in 1741, at the age of 26.

ARNAUD Belgard, a town of Turkey in Europe, in Albania. It is situated on the Chervesta, 40 miles N. E. of Vallona, in a fertile plain, covered with vines and olives. It is the seat of a Greek bishop, and contains 11,500 industrious inhabitants, who trade largely.

Arnaud de Meyrveilh, or Mereuil, a poet of Provence, who lived in the beginning of the 13th century. He wrote a book entitled *Las Recastenas de sa Contesse*, and a collection of poems and sonnets. Petrarch mentions him in his *Triumph of Love*. He died in the year 1220.

Arnaud de Ronsil, *George*, son of an eminent surgeon at Paris, and some time professor of surgery in the college of St Côsme. On account of an accident that occurred while he was practising midwifery, he removed from Paris to London, where he acquired great repute by his operations, and his writings on surgical subjects. Before his time the treatment of *hernia* had been but imperfectly understood; and the surgeons of this country are indebted to the observations of Arnaud for many of those improvements which have since rendered their practice so successful in this branch of the art. The following is a list of his principal works:—1, Traité des Hernies ou Descentes, 2 vols. 12mo, Paris, 1749. 2, Observations on Aneurysms, London, 1750. 3, Instructions on the Diseases of the Bladder and Urethra, London, 1763. 4, A Dissertation on Hermaphrodites, London, 1750. These were afterwards collected and published, with additions, under the title of Mémoires de Chirurgie, avec quelques Remarques sur l'Etat de la Médecine et de la Chirurgie en France et en Angleterre, 2 vols. 4to, London, 1768. 5, Remarks on the Use of the Extract of Lead of Goulard, London, 1776. Arnaud died in 1774.

Arnaud de Villa Nova, a famous physician, who lived about the end of the 13th and beginning of the 14th century. He studied at Paris and Montpelier, and improved himself by visiting the schools of Italy and Spain. He was well acquainted with languages, particularly with the Greek, Hebrew, and Arabic. His desire after the acquisition of knowledge was ardent, but it carried him too far in his researches. He put unlimited faith in astrology, and published a prediction that the consummation of the world would take place in the middle of the 14th century. He practised physic at Paris for some time; but having advanced some new doctrines, he drew upon himself the resentment of the university; and his friends, fearing he might be arrested, persuaded him to retire from that city. Upon his leaving France he went to Sicily, where he was received by king Frederic of Arragon with the greatest marks of kindness and esteem. Some time afterwards this prince sent him to France to attend pope Clement in an illness; and he was shipwrecked on the coast of Genoa about the year 1313. His works, with a life prefixed, were printed at Lyons in 1520, in one volume folio, and at Basil in 1585, with the notes of Nicholas Tolerus.

ARNAULD, Antony, a very celebrated doctor of the Sorbonne, was born in 1612. He published in 1643 *A Treatise on Frequent Communion*, which highly displeased the Jesuits; and the disputes upon grace, which broke out about this time in the university of Paris, and in which he took a zealous part with the Jansenists, helped to increase the animosity between him and the Jesuits. But nothing raised so great a clamour against him as the two letters he wrote *On Absolution;* in the second of which the faculty of divinity found two propositions which they condemned, and M. Arnauld was expelled the society. Upon this he retired; and during a retreat which lasted nearly twenty-five years, he composed that great variety of works which are still extant, on grammar, geometry, logic, metaphysics, and theology. In 1679 he withdrew from France, lived in obscurity in the Netherlands, and died in 1694. His heart, at his own request, was sent to be deposited in the Port Royal. Arnauld was a man of genius, remarkable for the strength of his memory and a command of his pen, which he possessed unimpaired to the last year of his life. Mr Bayle says, he had been told by persons who had been admitted into his familiar conversation, that he was a man very simple in his manners; and that unless any one proposed some question to him, or desired some information, he said nothing that was beyond common conversation, or that might make one take him for a man of great abilities; but when he set himself to give an answer to such as proposed a point of learning, he seemed as it were transformed into another man: he would then deliver a multitude of fine things with great perspicuity and learning. A complete collection of his works, extending to 45 vols. 4to, was published at Lausanne in 1777–83.

ARNAY-LE-DUC, a town of France, in the department of Cote d'Or, which carries on a pretty good trade. It is seated on the Auxois, in a valley near the river Aroux. Long. 4. 26. E. Lat. 47. 7. N.

ARNDT, John, a famous Protestant divine of Germany, born at Ballenstadt, in the duchy of Anhalt, in the year 1555. He died in 1621. His *Treatise on True Christianity* has been translated into several languages.

ARNE, Thomas Augustine, doctor of music, was born in King Street, Covent Garden, where his father was an upholsterer. He served three years with an attorney; but his strong propensity for music prevailed over the law, and he finally attached himself to the science, in which he soon became so eminent as to receive the degree of doctor from the University of Oxford in 1759. His compositions are numerous, he having adapted upwards of thirty musical pieces for the stage. They are characterized by a natural ease and elegance, a flow of melody, and a fullness and variety without affected or extraneous modulation. His most celebrated works are, *Artaxerxes*, which he paraphrased from Metastasio; the *Masque of Comus;* the *Opera of Operas*, a burletta; the *Guardian Outwitted;* and the *Rose;* some of which have taken a permanent hold of the stage. Dr Arne died March 5, 1778.

ARNHEM, one of the circles into which the province of Guelderland in the Netherlands is divided. It comprehends 14 cantons, and contains 74,451 inhabitants.

Arnhem, the capital city of the province of Guelderland, in the circle of the same name, on the banks of the Rhine. It is well built, and its fortifications being planted with trees, form a pleasing promenade. It is a place of little trade, but of some importance as a frontier town. It contains 1490 houses, and 9500 inhabitants. Long. 5. 38. 23. E. Lat. 51. 59. 58. N.

ARNISÆUS, Henningus, a philosopher and physician of great reputation about the beginning of the 17th century. He was born at Halberstadt in Germany, and was professor of physic in the university of Helmstadt. His political works are much esteemed. The most remarkable of them is his book *De Authoritate Principum in Populum semper Inviolabili*, printed at Frankfort in 1612. In this he maintains that the authority of princes ought not to be violated. He wrote also upon the same doctrine his three books, *De Jure Majestatis*, printed at the same place in 1610; and his *Reflectiones Politicæ*, printed at Frankfort in 1615. He went to Denmark by invitation, and was made counsellor and physician to the king. He travelled

into France and England, and died in November 1635. Besides the pieces already mentioned, he wrote several philosophical, medicinal, and poetical treatises.

ARNOBIUS, professor of rhetoric at Sicca, in Numidia, towards the end of the third century. Owing to certain dreams which he had, he became desirous of embracing Christianity, and for this purpose applied to the bishops for admission into the church; but his former violent hostility to the faith led them to distrust him, and, before they would consent, they insisted on some proofs of his sincerity. In compliance with this demand, he wrote against the Gentiles, refuting the absurdities of their religion, and ridiculing their false gods. In this treatise he has employed all the flowers of rhetoric, and displayed great learning; but from an impatience to be admitted within the pale of Christianity, he is thought to have been in too great a hurry in composing his work, as there does not appear in it so complete an order and disposition as could be wished; and not having a perfect and exact knowledge of the Christian faith, he published some very dangerous errors. Mr Bayle remarks, that his notions about the origin of the soul, the cause of natural evil, and several other important points, are highly pernicious. St Jerome, in his epistle to Paulinus, is of opinion that his style is unequal and too diffuse, and that his book is written without any method; but Dr Cave thinks this judgment too severe, and that Arnobius wants neither elegance nor order in his composition. Vossius styles him *the Varro of the ecclesiastical writers.* Du Pin observes that his work is written in a manner worthy of a professor of rhetoric: the turn of his sentiments is very oratorical; but his style is a little African, his expressions being harsh and inelegant. We have several editions of this work of Arnobius against the Gentiles; one published at Rome in 1542, at Basil in 1546 and 1560, at Paris in 1570, at Antwerp in 1582, and one at Hamburg in 1610, with notes by Geverard Elmenhorst, besides many others. He wrote also a piece entitled *De Rhetoricæ Institutione,* which is not extant.

ARNOLD, of Brescia, in Italy, distinguished himself, in the 12th century, by being the founder of a sect which opposed the wealth and power of the Roman clergy. He went into France, where he studied under the celebrated Peter Abelard. Upon his return to Italy he put on the habit of a monk, and opened his invectives in the streets of Brescia. He pointed his declamation against the bishops, the clergy, the monks, and finally against the Roman pontiff himself; to the laity only he was indulgent. In 1139 he was cited to appear before a grand council at Rome. His accusers were the bishop of Brescia, and many others, whom he had ridiculed and insulted. Nor from his judges could he look for much indulgence. He was found guilty, and sentenced to perpetual silence. Upon this he left Italy, crossed the Alps, and found a refuge in Zurich. After the death of pope Innocent II. he returned to Italy, and was ultimately condemned to death and executed in 1155. His name is chiefly deserving of being remembered for the boldness of his attempt to lower the power of the pope and his clergy, in an age when the papacy existed in all the plenitude of its power and influence.

ARNOLDISTS, in *Ecclesiastical History,* a sect so called from their leader Arnold of Brescia.

ARNOLDUS, Gothofredus, pastor and inspector of the churches of Perleberg, and historiographer to the king of Prussia, was born at Annaburg, in the mountains of Misnia, in 1666. He was a zealous defender of the Pietists, a sect among the German Protestants, and composed a great number of religious works, particularly an *Ecclesiastical History,* which exposed him to the resentment of the divines, and another giving an account of the doctrines and manners from the first ages, in which he frequently animadverts upon Cave's *Primitive Christianity.* He died in 1714.

ARNSTADT, a bailiwick in the principality of Schwazburg-Sanderhausen, in Germany. It contains 2 cities, 26 villages, and 5 hamlets, with 9700 inhabitants. The capital of the bailiwick is of the same name. It is divided by the river Werra into two portions, has walls, and a castle, in which a gallery of pictures is preserved, and where a porcelain manufactory is now carried on. A considerable trade is pursued in brewing, distilling, tanning, and the sale of grain. It contains 726 houses and about 4300 inhabitants. Long. 11. 3. 2. E. Lat. 50. 49. 57. N.

ARNSTEIN, a bailiwick in the circle of Lower Maine, in Bavaria, 66 square miles, or 42,200 acres, in extent. It is watered by the river Wehre, and, with the exception of 7000 acres in the southern part, which is woodland, is fruitful in corn, flax, and wine. It contains 1 city, 2 market-towns, and 37 villages, with 11,500 inhabitants. The capital of the bailiwick has the same name, and contains 350 houses, and 1800 inhabitants, who trade chiefly in wood-ware, corn, and wine.

ARNULPH, or Ernulph, bishop of Rochester in the reign of Henry I. He was born in France, where he lived some time a monk of St Lucien de Beauvais. The monks led most irregular lives in this monastery, for which reason he resolved to quit it, but first took the advice of Lanfranc, archbishop of Canterbury, under whom he had studied in the abbey of Bec, when Lanfranc was prior of that monastery. This prelate invited him over to England, and placed him in the monastery of Canterbury, where he lived a private monk till Lanfranc's death. When Anselm came to the archiepiscopal see, Arnulph was made prior of the monastery of Canterbury, and afterwards abbot of Peterborough. In 1115 he was consecrated bishop of Rochester, which see he held nine years, and died in March 1124, aged 84. Arnulph wrote a piece in Latin concerning the foundation, endowment, charters, laws, and other things relating to the church of Rochester: it is generally known by the title of *Textus Roffensis,* and is preserved in the archives of the cathedral church of Rochester. It has been printed in Thorpe's *Registrum Roffense.*

ARNWAY, John, a clergyman distinguished by his benevolence and loyalty to King Charles I., was descended from a very good family in the county of Salop, from which he inherited a considerable estate. He was educated at Oxford; and, having received holy orders, obtained the rectories of Hodnet and Ightfield, where he distinguished himself by his piety and exemplary charity; for it was his custom to clothe annually twelve poor people, and every Sunday to entertain as many at his table, not only plentifully, but with intimacy and respect. The civil war breaking out, he preached against rebellion, and raised and clothed eight troopers for the service of King Charles I., upon which his house was plundered by the parliament's army. He then went to Oxford to serve the king in person, which subjected him to a new train of misfortunes; for his estate was soon after sequestrated, and himself imprisoned till the king's death; after which he went to the Hague, where he published, 1, The Tablet, or the Moderation of Charles I. the Martyr; and, 2, An Alarm to the Subjects of England. He at last went to Virginia, where he died in 1653.

AROMA Philosophorum denotes either saffron or the aroph of Paracelsus; as *aroma Germanicum* denotes elecampane.

ARONA, a town of Italy, in the duchy of Milan, with a strong castle. It stands on the lake Maggiore. Long. 8. 25. E. Lat. 45. 41. N.

ARONCHES, a town of Portugal, in Alentejo, on the confines of Spain, seated on the river Caro. It is well fortified, and contains about 500 inhabitants. Long. 5. 16. W. Lat. 14. 39. N.

AROO, an island in the Eastern Seas, 140 miles in length by about 40 in breadth, lying to the south of Papua. The Chinese merchants settled at Banda carry on a traffic with this island, from which they procure pearls, edible birdnests, esteemed so great a delicacy by the Chinese epicures, tortoise shell, and stones. An aromatic vegetable substance called the Missoy bark is found here: it is also conjectured to be the haunt of the bird of paradise. The centre of the island is in long. 135. E. and lat. 6. S.

AROOL, a town of the empire of Russia, in the Ukraine, seated on the river Occa. Long. 38. 15. E. Lat. 51. 48. N.

AROPH, a contraction of *aroma philosophorum*, a name given to saffron.

Aroph Paracelsi, a name given to a kind of chemical flowers, probably of the same nature with the Ens Veneris, elegantly prepared by sublimation from equal quantities of lapis hæmatites and sal ammoniac.

AROSBAY, a town of the East Indies, on the coast of the island of Madura, near Java. Long. 14. 30. E. Lat. 9. 30. N.

AROURA, a Grecian measure of 50 feet. It was more frequently used for a square measure of half the plethron. The Egyptian aroura was the square of 100 feet.

ARPAGIUS, or Harpagius, among the ancients, a person who died in the cradle, or at least in early youth. The word is formed from the Greek ἁρπαζω, *I snatch*. The Romans made no funerals for their *arpagii*. They neither burnt their bodies, nor made tombs, monuments, or epitaphs for them; which occasioned Juvenal to say,

—— Terra clauditur infans
Et minor igne rogi.

In after-times it became the custom to burn such as had lived to the age of 40 days, and had cut any teeth; and these they called Ἁρπακτοι or Ἁρπαγμενοι, q. d. *rapti*, *ravished*. The usage seems to have been borrowed from the Greeks; among whom, Eustathius assures us, it was the custom never to bury their children either by night or full day, but at the first appearance of the morning; and that they did not call their departure by the name of *death*, but by a softer appellation, Ἡμερας ἁρπαγη, importing that they were ravished by Aurora, or taken away to her embraces.

ARPHAXAD, the son of Shem and father of Salah. Arphaxad was born in the year of the world 1658, a year after the deluge, and died in the year of the world 2096, at the age of 438.

ARPINAS, or Arpino, Joseph Cæsar, a famous painter, born in the year 1560, at the castle of Arpinas, in the kingdom of Naples. He lived in great intimacy with Pope Clement VIII. who conferred upon him the honour of knighthood, and bestowed many other marks of his friendship. In the year 1600 he went to Paris with Cardinal Aldobrandin, who was sent legate to the French court on the marriage of Henry IV. with Mary of Medici. His Christian majesty gave Arpinas many considerable presents, and created him a knight of St Michael. The colouring of this painter is thought to be cold and inanimate; yet there is spirit in his designs, and his compositions have somewhat of fire and elevation. The touches of his pencil being free and bold, give therefore pleasure to connoisseurs in painting; but they are generally incorrect. What he painted of the Roman history is the most esteemed of all his works. He died at Rome in 1640.

ARPINO, a city in the kingdom of Naples and province of Terra di Lavoro. It stands on a hill washed by the Fibreno, is tolerably well built, possesses a good market-place and 40 churches, with 9457 inhabitants, who carry on some considerable cloth manufactories. It is celebrated as the birthplace of Marius and of Cicero. Long. 14. 12. E. Lat. 41. 44. N.

ARQUA, a town of Italy, in the Paduan, and territory of Venice, remarkable for the tomb of Petrarch. Long. 11. 43. E. Lat. 45. 43. N.

ARQUES, a town of Normandy, now in the department of the Lower Seine, in France, seated on a small river of the same name. Long. 1. 30. E. Lat. 49. 54. N.

ARRACAN. This was formerly an independent kingdom; in 1783 it became a maritime province of the Burman empire, and was added to the British possessions in that quarter by the treaty of 1826, dictated by a British army at the gates of the Burmese capital. It is bounded by the Chittagong district on the north, from which it is separated by the small river Nauf; by Pegue on the south, in lat. 18. N.; on the west by the Indian Ocean; and on the east, at the distance of about 50 miles, it is divided from Ava by a range of mountains, through which there are very few passes. It may be estimated at 230 miles in extreme length, and in breadth 50; and the coast is studded with several fertile islands, viz. Ramree, Cheduba, &c. The mountains rise to the elevation of from 3000 to 5000 feet, and decline gradually towards the east in a succession of ranges. They were crossed in 1826 by Lieutenant Trant and a detachment of sepoys, and were found to abound in springs; and it appeared that a considerable commerce had been carried on to the eastward by this route previous to the British invasion. They were crossed farther to the south by Lieutenant Browne and a party of sepoys, and the country was found perfectly wild, and one continued succession of hills, jungles, and ravines. They extend northward as far as the southern bank of the Brahmaputra. The inhabitants of these mountains are averse to mix with the natives of the plains, although the Burmans, after their conquest of Arracan, compelled many, and allowed a few settlers from their native hills, to settle in the villages, where they are treated with humanity, in order to reconcile them to the restraints of civilization. A large proportion of these mountaineers are still independent, and have uniformly rejected a foreign yoke. A range of hills, very inferior in height, skirts the shore; and the valley which lies between them is covered with thick jungles and impenetrable woods, and filled with wild animals, such as the elephant, the tiger, &c. Owing to the moist temperature (the periodical rains continuing from June to November, and often to December, besides occasional showers), this tract of country is frequently flooded, and is at all times intersected with rivers, lakes, and inlets of the sea; so that the communication between the villages must be maintained by means of boats. The soil is fertile, especially in the vicinity of the mountains; but the frequent rains and exhalations under the burning sun of the tropics are adverse to European constitutions. The staple produce is rice, for which the country is well adapted, from its moist and hot climate. The other productions are sugar, hemp, indigo, onions, garlic, turmeric. The fruits are abundant and of a superior quality, viz. pineapples and plantains, mangoes, jacks, sweet limes, cocoa nuts, and other tropical fruits. The forests produce excellent timber; and the teak tree is found, but in such inaccessible parts, that it is usually imported from Rangoon. The rivers wash down from the mountains gold and silver particles, for the liberty of collecting which a certain rent is paid. Salt is produced in great abundance. Limestone is also procured from the islands that lie along the shore. The greater portion of the country is in a state of nature; and it is estimated by Hamilton, the accurate and well-

Arracan.

informed writer of the *East India Gazetteer*, that not above 400 square miles of this extensive territory are under cultivation. The inhabitants do not exceed 100,000, consisting chiefly of a rude and filthy race called the Mughs, about one third being Mahometans, and not more than one tenth Burmese. They speak their own language, which is different from the Burmese tongue; the principal Mahometans use the language of Hindostan, and the lower orders a mixed dialect.

The Mughs appear in their habits to be not far removed from the savage state. They give no attention to agriculture, but live by hunting, fishing, traffic, and rapine. They follow in their religion the Buddhist doctrines, with many Hindoo superstitions, and offer bloody sacrifices to the deities of the rivers, woods, and mountains. They are barbarous in their domestic manners, trafficking without restraint in slaves, and even pawning their wives when they are in want of money. Some bury their dead in coffins richly gilt, and others burn them. They are of a middling stature, but of a robust make, with broad faces, high and wide cheek-bones, flat noses, and, in the obliquity of their eyes, resembling the Chinese. They are so far addicted to the notions of the Hindoos that they scruple about taking the life of an animal; but when dead they eat every species of animal without restraint, and are of the most disgusting and filthy habits in their eating as well as in their persons. Besides the tribes on the sea-coast, there are many rude tribes scattered in the interior, and beyond its limits to the east, as well as those of Chittagong. These different tribes are frequently engaged in mutual hostilities. It has been from time immemorial the practice of these Mughs, like most of the other barbarous nations of Asia, to make predatory inroads on the southern parts of Bengal, and to carry off all the booty which they could collect, including men, women, and children, who are sold for slaves. They have even had the boldness to descend on the coast of Chittagong, to proceed into the country, plunder and burn the villages, destroy what they could not carry away, and make slaves of the inhabitants. It was to an incursion of this sort in 1777 that we owe our first knowledge of this country. In February 1776 it is mentioned by Major R. E. Roberts,[1] who was residing at Islaamabad, that a body of them made an inroad on the southern parts of Bengal, and carried off about 1800 men, women, and children, who were brought to Arracan, where the rajah was allowed his choice from the female captives; after which the remainder were conducted with ropes about their necks to the market-place, and being there sold, were employed in the cultivation of the lands and other laborious employments. It was from some of those captives who escaped that any information was obtained of this eastern country.

Before the province of Chittagong was ceded to the company, the British territories were frequently exposed to the inroads of these plunderers, and an immense expense was incurred in maintaining a sea and land force to repel them; and there are still vestiges of a fortification round the town of Islaamabad, which was raised up by the inhabitants as a defence against their inroads. Even the possession of the province of Chittagong, owing to the extent of its coast, did not wholly prevent their attacks; and a considerable force was still found necessary for the protection of the company's territories, which were from time to time molested by their hostile incursions; and Major R. E. Roberts, in an account of Arracan, published in the *Asiatic Miscellany* at Calcutta in 1777, observes, with a singularly penetrating and almost prophetic spirit, when he is pointing out the impolicy of merely acting on the defensive against these marauders, "The longer they continue unattacked the more powerful and outrageous they will become, till at last it will be found necessary, for the immediate preservation of all the southern parts of Bengal, to enter into an expensive and perhaps bloody war with them."

Arraca

Arracan, from the character of its inhabitants, who are rude and indolent, possesses no surplus produce with which to trade to other countries; and salt is the only article of export. This country was formerly the medium of commercial intercourse between Asia and Hindostan, exporting to the former European goods, such as velvet, broad cloths, piece goods, silks, muslins, betel-nut, salt, &c., and receiving in return ivory, silver, copper, sugar, tobacco, oil, and lacquered ware. The country being so poor and unproductive, produces only about 220 rupees of revenue, which will hardly defray the expense of its civil and military establishments; and it is retained, not for profit, but as an outpost of defence against the incursions and growing power of the Burmese empire.

The natives of Arracan trace their history as far back as A. D. 701, and give a lineal succession of 120 native princes down to modern times. According to them their empire had at one time far wider limits, and extended over Ava, part of China, and the Bengal territories. This extension of their empire does not agree with any known facts in history. At different times the Moguls and Peguers carried their arms into the heart of the country. The Portuguese, during the era of their greatness in Asia, gained a temporary establishment in Arracan. But in 1783 the province, with all its dependencies, was finally conquered by the Burmese; and though the inhabitants made desperate efforts to recover their independence, they were always foiled by the discipline and numbers of their enemies, who contrived to extract from this ill-cultivated tract a surplus revenue of 18,000 rupees. In 1825 the British army in Arracan became a prey to the destructive climate, and died in great numbers; and it has since proved equally injurious to the native regiments stationed on the coast.

ARRACAN, the capital of the above province, situated on a river of the same name, about 40 miles from the sea. The town is chiefly built of bamboo huts, and stands in a valley surrounded by hills, and covered with marshes and canals, communicating with a number of small streams, running between low muddy banks. The tide overflows to a considerable extent the flat borders of the river Arracan, and by its reflux converts these into a pestilential swamp, on which a great part of the town of Arracan is built. In such an unfavourable situation, it is necessary to drive wooden posts into the ground to obtain a foundation for the houses, under which the water flows. We need not wonder that a place so situated should be unhealthy for Europeans. The town is perpetually involved in the putrid exhalations from these swamps, which are a perpetual source of disease. Where the ground is not swampy it consists of a soft species of rock. The surrounding ground is irregularly diversified by hills, connected by narrow ridges, and separated by ravines, either occupied by a stream or a marsh. The houses are connected by wooden bridges; and in its centre is a square surrounded by a wall containing pagodas and images of Gaudma, of all sizes, from an inch to 20 feet in height. The town and fort were taken by the Burmese in 1783.

[1] *Asiatic Annual Register*, vol. i.

It was taken by the British army in 1825, and was found to be in a most miserable condition, and the air most pestilential.

ARRACK, a spirituous liquor manufactured at several places in the East Indies, namely, Goa, Columbo, and Batavia. In India every kind of spirituous liquor is known under the general appellation of arrack; and hence the various accounts given of the mode of making it, and the materials used. English gin is called by the natives English arrack,—and it is certain that the several kinds of arrack differ as much in flavour as brandy, rum, or any other spirituous liquor. The manufacture of arrack was formerly carried on by the Portuguese at Goa, but the art of making it has been transferred for the most part from that place to Batavia.

Goa and Batavia are the chief places for arrack. At Goa there are divers kinds; single, double, and treble distilled. The double distilled, which is that commonly sent abroad, is but a weak spirit in comparison with Batavia arrack; yet, on account of its peculiar and agreeable flavour, is preferred to all the other arracks of India. This flavour is attributed to the earthen vessels which they use at Goa to draw the spirit; whereas at Batavia they use copper stills.

The Parier arrack made at Madras, and the Columbo and Quilone arrack at other places, being fiery, hot spirits, are little valued by the Europeans, and therefore rarely imported, though highly prized among the natives. In the best Goa arrack, the spirits of the cocoa juice do not make above a sixth or eighth part.

The Goa arrack is invariably made from a vegetable juice called toddy, which flows by incision from the cocoa-nut tree. When a sufficient quantity of toddy is procured, it is left to ferment, which it soon does. When the fermentation is over, and the liquor or wash is become a little tart, it is put into the still; and a fire being made, the still is suffered to work as long as that which comes over has any considerable taste of spirit. The liquor thus procured is the low wine of arrack; and this is so poor a liquor, that it will soon corrupt and spoil if not distilled again, to separate some of its phlegm; they therefore immediately after pour back this low wine into the still, and rectify it to that very weak kind of proof spirit, in which state we find it. The arrack we meet with, notwithstanding its being of a proof test, according to the way of judging by the crown of bubbles, holds but a sixth, and sometimes but an eighth part of alcohol, or pure spirit; whereas our other spirits, when they show that proof, are generally esteemed to hold one half pure spirit.

Batavia arrack is obtained by distillation from rice and sugar. A hot, fiery spirit is imported into Batavia by the Chinese Junks, called samshew, which is mixed with arrack, and which is chiefly consumed by the Chinese who reside in that settlement.

The following are the East India Company's regulations for shipping arrack, &c. No arrack or other spirits are permitted to be shipped in India or China in any of the Company's ships returning to Europe, except for the use of the ship's company on the voyage, or in the immediate privilege of the commander and officers. Each cask or chest shipped for the use of the ship's company must be marked "stores;" and those shipped on the private account of any of the officers shall be marked with the name at length of the person to whom it belongs; and such casks or chests as shall not be so marked shall be taken and deemed to be the property of the commander. The tonnage of arrack is calculated at 252 gallons per ton.

ARRAGON. See Aragon.

ARRAIGNMENT, in *Law*, the arraigning or setting a thing in order, as a person is said to arraign a writ of novel disseisin, who prepares and fits it for trial; but this term more properly denotes the calling of a person to answer in form of law upon an indictment, &c.

ARRAN, an island on the west coast of Scotland, near the mouth of the river Clyde, which forms part of the county of Bute. It is about 20 miles in length by from 8 to 11 in breadth, and contains a superficial area of 165 square miles, or 105,814 acres, of which about 14,431 are cultivated. This island is of an extremely rugged and mountainous surface, particularly in the northern part, in which the valleys are deep and romantic. The principal mountain is Goatfell, which rises, according to accurate measurement, 2685 feet above the level of the sea, and is clothed with lichens and mosses. A few others approach to the same elevation. There are five small lakes in the island, from which two streams have their source. The quadrupeds are not numerous. There are a few red deer, the remains of a numerous breed, which are said still to find shelter among the mountains; and wild goats are still harboured in those parts. The cattle and sheep, which were formerly small, have been improved by the introduction of a larger breed. The birds are eagles, hooded crows, plovers, curlews, black cock, and other species of grouse, which are exceedingly numerous in the mountains. Ptarmagans, which were formerly seen, have now disappeared. Limestone, marl, and slate, are found in different parts, and there are also indications of coal; while in the mountains are found marble, jasper, agates, cairngorms, and a fine species of rock-crystal called the Arran diamond. Shoals of herring frequent the shores, and the herring fishery is prosecuted to a great extent. No less than 200 fishing vessels, well manned and properly fitted out, and belonging to the island, are employed in it. Arran has two remarkably fine harbours, Lamlash on the east side, and Loch Ranza on the other. Formerly the style of agriculture was extremely rude and imperfect; but the improved system has now been adopted in all its branches. Most of the high land was at one time a common, on which the cattle of all the tenants was indiscriminately pastured. The whole of the cultivated land is now subdivided and inclosed, and the hills laid out in sheep-walks. Flax is cultivated in small quantities, and linens and some woollens are manufactured. With the exception of a few farms, the whole island belongs to the Duke of Hamilton, who has very lately begun to take an interest in its improvement, and expended a considerable sum in making roads, bridges, and small harbours. It has several castles of great antiquity; one, the castle of Brodick, which was garrisoned by Sir J. Hawkins in the reign of Edward II.; another at Lochvanza, built by Robert II. as a hunting seat. Population 6754.

ARRAS, an arrondissement in the Pas de Calais, in France, extending over 552 square miles, or 353,280 acres. It is divided into nine cantons, and these into 218 communes, containing 143,615 inhabitants. The chief city of the arrondissement has the same name. It is situated at the influx of the Erinchon into the navigable river Scarpe. It is regularly fortified with a citadel, built by Vauban, with bomb-proof casemates. The city is well built, with regular and lofty houses. The cathedral is a sumptuous Gothic edifice, besides which there are twelve parish churches, the Abbey of St Wast, now the barracks, and some other fine public edifices. The inhabitants, 19,498 in number, are generally very industrious, and carry on extensive manufactories of fine linen and of lace, besides which there are establishments for refining sugar, for making soap, salt, starch, several breweries, and mills for spinning cotton. The manufactories have, however, declined considerably since the peace. It is the birthplace of the as-

sassin Damiens, and of the two brothers Robespierre. It is in long. 2. 50. 54. E. and lat. 50. 17. 37. N.

ARRAY, in *Law*, the ranking or setting forth of a jury, or inquest of men impannelled on a cause.

ARRAYERS, ARRAGERS, or ARRAITORES, is used in some ancient statutes for such officers as had care of the soldiers' armour, and saw them duly accoutred in their kinds. In some reigns commissioners were appointed for this purpose.

ARRENTATION, in the forest laws, implies the licensing the owner of lands in a forest to inclose them with a low hedge and a small ditch, in consideration of a yearly rent.

ARREOYS. Among the more singular secret societies which mankind have formed, is one in Otaheite and the neighbouring islands for the destruction of their own species, called *Arreoy*, *Arehoe*, or *Earowie;* and it is not a little remarkable that it should subsist among tribes distinguished for courteousness and humanity. We read in the older authors that there is an absolute prohibition against the females of Formosa rearing children before the age of thirty-six, though it does not appear that there is any limitation as to the age at which their espousals may take place. But in the event of pregnancy, it is necessary that abortion should follow, which is accomplished by the aid of the priestesses of the island. Among the Arreoys, however, extirpation of the infant being constitutes the leading feature of their ordinances.

Whether Mendana, Quiros, and the earlier navigators of the South Pacific Ocean, discovered this society, does not appear: it has, at any rate, been reserved for those of later date to unfold its principles and peculiarities, though, indeed, its constitution is still enveloped in much mystery, the members being bound to the strictest secrecy.

The society of Arreoys consists of hundreds or perhaps thousands of both sexes, who engage to destroy their own offspring at the moment of birth. It is chiefly composed of persons distinguished by valour and merit, and hence one or more individuals of each family of the chiefs are of the number. It has been remarked, that all the men profess themselves warriors, and are in general stout and well made; that the greatest trust and confidence are reposed in them; and it rather appears that the women consist of the higher ranks only. There are different gradations in this community, which are to be recognised from the mode of tattooing: the more profusely the men are tattooed, the higher is their rank in society; the first are called *Ava bly areema tutowe;* 2, *Areema bly;* 3, *Ahowhoa;* 4, *Harrotea;* 5, *Eote ole;* 6, 7, *Po;* and youths training up are designed *Mo;* but the meaning of these names is not explained. By the fundamental laws of the society, the offspring must be destroyed, yet it is not known with certainty by whom or in what particular manner; the murder is always perpetrated in secret, probably by strangulation; all the attendants are excluded; for it is said, were they to witness it they would be adjudged guilty of participation, and put to death. Sometimes the mother, animated by natural affection, tries to preserve her infant, and resists the persuasions of her husband and his brother Arreoys, who wish to consign it to destruction. But in general the enormity of the crime does not appal the females, though they are described to be affectionate and tender. We find a dancing girl pregnant by an Arreoy expressing herself thus to the English navigators: "Perhaps the *Etooa* or deity of England might be offended with the practices of the Arreoys, but her own was not displeased with them. However, she promised if we would come from England for her child, she might perhaps keep it alive, provided we gave her a hatchet, a shirt, and some red feathers." That the rules of the community are very strict, may be inferred from an instance given by Captain Bligh. A chief, a member of the society, married a sister of the king of Otaheite, by whom he had eight children, and the whole were destroyed at their birth! Nor did this enormity seem to originate from any other source, as the parents afterwards adopted a nephew as their heir.

It may here be observed, that there are other practices among these people regarding infanticide, which, though we want materials for positively affirming the fact, may perhaps be connected with the institutions of the Arreoys. When an Otaheitan chief has a child by a woman of the lower orders, it is never suffered to live; and the like seems to take place reciprocally among the higher ranks of females. The king and queen of Otaheite having ceased to cohabit, he had taken another wife, and she associated with one of her attendants of low rank. When pregnant, the missionaries endeavoured to persuade her to spare her child, which she said she would have done had it been her husband's, but now it would be base-born, and must perish; and she resisted all entreaties to the contrary. Afterwards, having visited them, she excused herself for having put the infant to death, stating that it was the custom of the country to murder all base-born children, and hers being by a low man, she had only complied with the usual practice. Indeed it is affirmed by the missionaries who visited that island in 1797 to be a common proceeding among all ranks to strangle infants the moment they are born. "A perpetrator of this horrid act," the narrator observes, "was among those whom curiosity attracted to visit us. She was a good-looking woman, and esteemed by the natives a great beauty, which I suppose to be the inducement that tempted her to murder her child; for here the number of women bearing no proportion to the men, those esteemed handsome were courted with great gifts, and got so accustomed to change their husbands, to go with them from place to place, and run after the diversions of the island, that rather than be debarred those pleasures, they stifle a parent's feelings, and murder their tender children." Thus many hundreds born into the world are never suffered to see the light; and so little criminality in the opinion of the natives is attached to the deed, that many women disclose the number they have put to death without scruple. It has been calculated that at least two thirds of the births on the island perish in this manner.

The Arreoys enjoy great privileges, and are everywhere united by the reciprocal ties of friendship and hospitality. When they visit different islands, they receive presents, and are entertained with feasting and dramatic exhibitions; and all this they seem to expect rather as a matter of right than of courtesy. Their clothes are of the finest materials. They pass their time in luxurious idleness, perfuming their hair with fragrant oils, singing and playing on the flute, and passing from one amusement to another. "Wherever they go," says Forster, "the train of sensual pleasure awaits them." They feast on the choicest vegetables; and an abundance of dogs' flesh and poultry are liberally provided by the lower classes for their entertainment. They are copiously supplied with *kava;* and for them are performed nocturnal sports of music and lascivious dances, to which no other spectators are admitted. Their presence seems to enliven the whole country; and among the various entertainments to which it gives birth, is one called *hopowpah*, of a dramatic nature, in which they themselves act a part. As soon as one Arreoy visits another, though a stranger, he immediately has his wants supplied and his wishes gratified; he is introduced to other members, who vie with each other in loading him with courtesies and presents. They are of all others the

most luxurious and profuse, often consuming the whole provisions of a district. When Captain Cook lay at Huaheine, no less than 70 canoes were observed crossing over to another island with 700 Arreoys on board; and thus they keep great meetings at appointed times, and travel in companies from one island to another. It has been affirmed, but perhaps without sufficient foundation, that a promiscuous intercourse of the sexes prevails in their society; however, they are permitted great latitude in their amours, except in times of danger, as almost all are fighting men. Sufficient inducements are, therefore, held out to be admitted into this mysterious community.

Any one may withdraw at pleasure from the society; and an example is given of a chief who had killed his first-born child, but preserved the second, having withdrawn in the interval. A woman who ceases to be an Arreoy incurs a reproachful name, signifying "bearer of children." Thus, while in most other countries the name of parent confers honour and respect, among the Arreoys of Otaheite it is used as a term of contempt and reproach. A chief of some repute, hearing that the king of Great Britain had a numerous offspring, declared that "he thought himself a much greater man, because he belonged to the Arreoys."

With respect to the origin of this society, Forster was the first to offer any conjectures. "In a country," says he, "which has emerged so lately from barbarism as Otaheite, we cannot suppose that such a community, which is evidently injurious to the rest of the nation, would have maintained itself to the present time, were not its advantages so considerable as to require its continuance." There are two causes, he adds, which favour the existence of the Arreoys; first, the necessity for entertaining a body of warriors to defend their fellow-citizens from the invasions and depredations of enemies; secondly, it was necessary, by such an association, to prevent the too rapid increase of the number of their chiefs. "Perhaps," he remarks, "some intelligent Otaheitan lawgiver might foresee that the common people would at length groan under the yoke of such petty tyrants, whose number was ever multiplying." The ordinary practice of infanticide is ascribed by Mr Wilson, who visited the South Seas in 1801, merely to the love of pleasure and avarice, which latter passion had gained great ascendancy since the intercourse of the islanders with Europeans: "being well aware," says he, "that the beauty of females rearing families experiences an earlier decay, it is anxiously preserved for their visitors, by destruction of their offspring, or even by procuring abortion." Before offering any opinion on this point, we shall notice a custom in the north-west of India somewhat analogous, which also is attended with mystery.

Amongst certain tribes called Jarejahs, which are more particularly disseminated in the peninsula of Guzerat, the whole females are devoted to death at the moment of their birth. But this is in consequence of general custom, not of any special association. The immediate death of a daughter is viewed as the inevitable consequence of its birth; and the innocent beings falling a sacrifice to this barbarous ordinance yearly amount to many thousands. When a woman is delivered of a daughter, the event is communicated by the female attendants to the father, who desires them to do as is customary; an injunction said to be followed by the mother applying a little opium on the nipple of her breast, which is sucked in by the child. More usually it is strangled by herself, or drowned in a basin of milk; but women of rank, who have attendants, never perform the office themselves. However, from the mystery observed, it is, as among the Arreoys, difficult to obtain correct information. In some districts, any of the female attendants may put the infant to death; in others, a kind of domestic priest becomes the executioner; and the infant being placed naked in a small basket, it is carried out to be interred, for which he receives a trifling fee. Among the Arreoys, those who preserve their children seem to suffer a degree of degradation; and they plead as an apology for their destruction, that it is necessary to preserve the privileges of their tribe. With the Jarejahs, the father is obeyed on signifying his desire for preservation; but if he continues silent on receiving the intelligence, the usual custom must be complied with. The mother is generally averse to the sacrifice, but her scruples to preserve her offspring are seldom attended to; should a short interval elapse, however, before the bloody deed is done, it then becomes unlawful, and the child must be spared.

Perhaps the murderous practices of the Arreoys in the South Sea islands may have originated in some religious principle. At the same time, it appears that, in the ordinary destruction of infants by the islanders of the South Pacific Ocean, there is nothing of a sacrificial nature; for though they do not suppose that their displeasure is thereby incurred, they do not pretend that the practice is acceptable to any of their divinities. Mr Malthus, we may add, ascribes the origin of the Arreoy institutions to a superabundance of population, and the necessity of adopting some forcible expedients to bring it within the limits of subsistence. (See Forster's *Voyage*, vol. ii.; Cook's *First and Second Voyages*; Bligh's *Voyage*; *Missionary Voyage*; Hamilton's *Account of the Loss of the Pandora*.)

ARREST, in *English Law* (from the French word *arrester*, to *stop* or *stay*), is the restraint of a man's person, obliging him to be obedient to the law, and is defined to be the execution of the command of some court of record or office of justice. Arrests are either in *civil* or *criminal* cases. 1*st*, An arrest in a *civil cause* is defined to be the apprehending or restraining one's person by process, in execution of the command of some court. 2*d*, An arrest in a *criminal cause* is the apprehending or restraining one's person in order to be forthcoming to answer an alleged crime.

Arrests by private persons are in some cases commanded. Persons present at the committing of a felony must use their endeavours to apprehend the offender, under penalty of fine and imprisonment; and they are also, with the utmost diligence, to pursue and endeavour to take all those who shall be guilty thereof out of their view, upon a hue and cry levied against them. By the vagrant act, 17 Geo. II. cap. 5, every person may apprehend beggars and vagrants; and every private person is bound to assist an officer requiring him to apprehend a felon.

In some cases, likewise, arrests by private persons are rewarded by law. By the 4 and 5 William and Mary, cap. 8, persons apprehending highwaymen, and prosecuting them to a conviction, are entitled to a reward of L.40; and if they are killed in the attempt, their executors, &c. are entitled to the like reward. By the 6 and 7 William III. cap. 17, persons apprehending counterfeiters and clippers of the coin, and prosecuting them to conviction, are entitled to L.40.

By 5 Anne, cap. 31, persons who shall take any one guilty of burglary, or the felonious breaking and entering any house in the daytime, and prosecute them to conviction, shall receive the sum of L.40, within one month after such conviction.

With regard to arrests by public officers, as watchmen, constables, &c. they are either made by their own authority, which differs but very little from the power of a private person; or they are made by a warrant from a justice of peace.

Arrest of Judgment, in *Law*, is the assigning just reason why judgment should not pass; as, want of notice of the trial; a material defect in the pleading; when the record differs from the deed impleaded; when persons are misnamed; where more is given by the verdict than is laid in the declaration, &c.

ARRESTMENT, in *Scots Law*, denotes that diligence by which a creditor detains the goods or effects of his debtor in the hands of third parties till the debt due to him shall be paid.

ARRHABONARII, a sect of Christians, who held that the eucharist is neither the real flesh nor blood of Christ, nor yet the sign of them; but only the pledge or earnest thereof.

ARRHEPHORIA, a feast among the Athenians, instituted in honour of Minerva, and of Herse, daughter of Cecrops.

ARRIAN, a philosopher and historian, who flourished in the time of the emperor Adrian and the two Antonines, was born at Nicomedia in Bithynia. His learning and eloquence procured him the title of *The Second Xenophon*, and raised him to the most considerable dignities at Rome, even the consulship itself. Many of his pieces have been lost. Of his dissertations upon Epictetus, there have been preserved four of the eight books which he wrote. His history of the expeditions of Alexander the Great, in seven books, is the most valuable of his remains. The work entitled the *Periplus of the Red Sea* has been ascribed to him by many, but, as Dr Vincent contends, erroneously. (See Vincent, Dr William.) The best editions of Arrian are those of Gronovius and Schmeider; the one published in 1704, the other in 1798.

ARRIEGO, a department of France, bounded on the east by Aude, on the south-east by the Eastern Pyrenees, on the south by the mountains, and on the west and north by the department of the Upper Garonne. Its extent is 244 square miles, or 143,360 acres. It sends two deputies to the Chamber, is in the diocese of Pamiers, and within the jurisdiction of the royal tribunal of Toulouse. It contains three arrondissements, 20 cantons, and 330 communes. The population by the last returns appears to be 229,760 inhabitants. The chief towns are Tarascon, Aix, and Mirepoix.

ARROE, a small but very fruitful island in the Baltic, to the south-west of Funen. Its greatest length is three Swedish miles, but its breadth is not more than half a mile. It belongs to the duchy of Sleswick, and came definitively to the crown of Denmark in the year 1749. Firewood is scarce, as every spot of ground is under tillage. The horses and black cattle are in good condition. Agriculture, navigation, and fishing, are the chief sources of income. Population above 4500. Long. 10. 20. E. Lat. 54. 53. N.

ARROYO del Puerto, a town of Spain, on the Ayuda, in the province of Estremadura, containing 5000 inhabitants. There is a pottery here, which employs 52 workmen, and furnishes 208,000 pieces of ware annually.

ARROW, a missile weapon of offence, slender pointed and barbed, to be cast or shot with a bow. See Archery.

Arrow-Makers are called *fletchers*, and were formerly, as well as bowyers, persons of great consequence in the commonwealth.

ARSACES, otherwise Mithridates, a king of the Parthians, spoken of in the first book of Maccabees. He considerably enlarged the kingdom of Parthia by his good conduct and valour.

ARSAMAS, a circle of the Russian government of Nishegorod, between long. 43. 21. and 44. 10. E. and lat. 54. 37. and 55. 28. N. It is watered by the rivers Tescha and Scholka, which flow to the Volga. It is an undulating country; much of it is covered with wood, and some part of it with swamps; but it produces flax in abundance, and corn sufficient for the use of the inhabitants, who amount to 120,000, of whom 4351 are slaves belonging to the crown, and 23,643 belonging to other individual nobles. The chief employment is wood-cutting, potash burning, and spinning linen yarn.

Arsamas || Art.

Arsamas, the capital of the Russian circle of the same name, at the junction of the river Scholka with the Tescha. It is an old and ill-built city, with 20 wood and 2 stone churches, some other public buildings, 1416 houses, and about 8000 inhabitants. There are some manufactures of the leather peculiar to Russia, of soap, and of woad; and many shoes are made for distant markets. The merchants deal largely in linen and sail-cloth. It is in lat. 55. 27. N. and long. 43. 46. E.

ARSENAL, a royal or public magazine, or place appointed for the making and keeping of arms necessary either for defence or assault. Some derive this word from *arx*, a *fortress*; others from *ars*, denoting a *machine*; others again from *arx* and *senatus*, because this was the defence of the senate; but the more probable opinion derives it from the Arabic *darsenaa*, which signifies *arsenal*. The arsenal of Venice is the place where the galleys are built and laid up. The arsenal of Paris is that where the cannon or great guns are cast.

ARSENIUS, a deacon of the Roman church, of great learning and piety. He was appointed by the pope to go to the emperor Theodosius, as tutor to his son Arcadius. Arsenius arrived at Constantinople in the year 383. The emperor happening one day to go into the room where he was instructing Arcadius, his son was seated and the preceptor standing. At this he was exceedingly displeased, took from his son the imperial ornaments, made Arsenius sit in his place, and ordered Arcadius for the future to receive his lessons standing uncovered. Arcadius, however, profited little by his tutor's instructions, for some time after he formed a design of dispatching him. The officer to whom Arcadius had applied for this purpose divulged the affair to Arsenius, who retired to the deserts of Scete, where he passed many years in the exercises of the most strict and fervent devotion. He died there, at 95 years of age.

ARSHOT, a town of the Austrian Netherlands, situated about 14 miles east of the city of Mechlin, in long. 4. 45. E. lat. 51. 5. N.

ARSON, in *English Law*, is the malicious and wilful burning of the house or outhouse of another man; which is felony at common law.

ARSURA, in ancient customs, a term used for the melting of gold or silver, either to refine them or to examine their value. The method of doing this is explained at large in the Black Book of the Exchequer, ascribed to Gervaise, in the chapter *De Officio Militis Argentarii*, being in those days of great use, on account of the various places and different manners in which the king's money was paid.

Arsura is also used for the loss or diminution of the metal in the trial. In this sense a pound was said *tot ardere denarios*, to lose so many pennyweights.

Arsura is likewise used for the dust and sweepings of silversmiths, and others who work in silver melted down.

ARTA, or Larta, a town of Lower Albania, in European Turkey, containing about 6000 inhabitants, Turks and Christians, who carry on a trade in cattle, wine, tobacco, cotton, flax, pulse, fur, leather, wheat, &c. They also manufacture cotton and woollen stuffs. Arta is situated about 9 miles from the gulf to which it gives name, otherwise called Prevesa. Long. 21. 8. E. Lat. 39. 30. N.

ARTABA, an ancient measure of capacity used by the

Persians, Medes, and Egyptians. The Persian artaba is represented by Herodotus as larger than the Attic medimnus by three Attic chœnixes: from which it appears that it was equal to $6\frac{1}{4}$ Roman modii; consequently it contained $166\frac{2}{3}$ pounds of wine or water, or $126\frac{2}{3}$ pounds of wheat. The Egyptian artaba contained five Roman modii, and fell short of the Attic medimnus by one modius; it consequently held $133\frac{1}{3}$ pounds of water or wine, or 100 pounds of wheat.

ARTABAZUS, the son of Pharnaces, commander of the Parthians and Chorasmians in the famous expedition of Xerxes. After the battle of Salamis he escorted his sovereign to the Hellespont with 60,000 chosen men; and after the battle of Platæa, in which Mardonius engaged in opposition to his wishes and advice, he made a noble retreat into Asia with 40,000 men under his command.

ARTAXERXES, the name of several kings of Persia. See PERSIA.

ARTEDI, PETER, an eminent naturalist, was born in Sweden in the year 1705, in the province of Angermania. Although his parents were poor, yet it appears they found means to give him a liberal education, and with this view sent him to the college of Hurnesand. Intending to embrace the ecclesiastical profession, he went in 1724 to Upsal; but he turned his attention to medicine from the strong bent of his mind for the study of natural history, in which science he made rapid progress, and soon rose to considerable eminence, particularly in the department of ichthyology. Confining his botanical studies to the umbelliferous plants, he suggested a new mode of classification. But Artedi was much better acquainted with chemistry than botany. His attention, however, was chiefly directed to ichthyology, the classification of which he greatly reformed, and new-modelled upon philosophical principles. This arrangement added greatly to his reputation as a naturalist at the time, and afterwards became popular over Europe. In 1728 his celebrated countryman Linnæus arrived in Upsal, having been appointed to deliver lectures on botany in that place; and so high stood the character of Artedi as a philosopher, that a lasting friendship was formed between these two great men. In 1732 both left Upsal; Artedi for England, in pursuit of his favourite study, and Linnæus for Lapland, to examine its natural productions; but before parting, they reciprocally bequeathed to each other their manuscripts and books upon the event of death. However, in the year 1735 they met again at Leyden, where Artedi was introduced to Seba, and employed in preparing for the press the third volume of that eminent naturalist's *Thesaurus*, which chiefly related to fishes. Artedi formed the resolution, as soon as that work was finished, to return to his native country, and publish the fruits of his own labours; but as he was returning home from Seba's house on the evening of the 27th September 1735, the night being dark, he fell into the canal and was unfortunately drowned. According to agreement, his manuscripts came into the hands of Linnæus, and his *Bibliotheca Ichthyologica* and *Philosophia Ichthyologica*, together with a life of the author, were published at Leyden in the year 1738

ARTEMIDORUS, famous for his Treatise on Dreams, was born at Ephesus, and lived under the emperor Antoninus Pius. He styled himself *the Ephesian* in all his performances but that on Dreams, where he took the cognomen of Daldianus, in compliment to his mother country Daltis. On this work he expended vast labour, not only possessing himself of all that had been written on the subject, but travelling for years in search of fortune-tellers, as well as corresponding with them in various parts, and collecting information on old dreams, and the events which were said to have followed them. It consisted of five books, and, though abounding in frivolous observations, contained others that were interesting. It was first printed in Greek at Venice in 1518; and Rigaltius published an edition at Paris, in Greek and Latin, in 1603, to which he added some notes. Artemidorus wrote also a treatise upon Auguries, and another upon Chiromancy, but they are not now extant.

ARTEMISIA, wife of Mausolus, king of Caria, has immortalized herself by the honours which she paid to the memory of her husband. She built for him, in Halicarnassus, a very magnificent tomb, called the *Mausoleum*, which was one of the seven wonders of the world, and from which the title of *Mausoleum* was afterwards given to all tombs remarkable for their grandeur; but she died of regret and sorrow before it was finished. She appointed panegyrics to be made in honour of him, and proposed a prize of great value for the person who should compose the best. She died about the end of the 106th Olympiad, 351 years before the Christian era.

ARTEMISIA, queen of Caria, and daughter of Ligdamis, marched in person in the expedition of Xerxes against the Greeks, and performed wonders in the sea-fight near Salamis, 480 years before the Christian era. She was passionately fond of a man named Dardanus, of Abydos; but, enraged at his neglect of her, she put out his eyes while he was asleep. The gods punished her for this, by increasing the passion she entertained for him; so that the oracle having advised her to go to Leucas, which was the usage of desperate lovers, she took the leap from thence, and was interred at that place. Many writers confound this Artemisia with the former, the wife of Mausolus.

ARTEMISIUM, in *Ancient Geography*, a promontory on the north-east of Eubœa (called *Leon* and *Cale Acte* by Ptolemy), memorable for the first sea engagements between the Greeks and Xerxes.

ARTHUR, the celebrated hero of the Britons, is said to have been the son of Uthor Pendragon, king of Britain, and to have been born in 501. His life is a continued series of wonders. It is said that he killed 470 Saxons with his own hand in one day; and, after having subdued many mighty nations, and instituted the order of the Knights of the Round Table, died A. D. 542, of wounds which he received in battle. The most particular detail of his story and his exploits is that given by Geoffroy of Monmouth; but there the probable is so blended with the marvellous and extravagant, that not only the truth of the whole, but even the reality of Arthur's existence, has been called in question. In this controversy Mr Whittaker has taken much pains, in his *History of Manchester*, to vindicate the existence, and discriminate between the real and the fabulous transactions, of the British worthy. But a severe critic might be apt to say that it requires much faith in the author's judgment, not to suspect that he sometimes allows too much scope to fancy and conjecture. According to Mr Whittaker, Arthur's principal exploits were against the northern Saxons, whilst he was only prince of the Silures, and Ambrosius was the dictator or pendragon of the Britons. "In a series probably of five campaigns, and in a succession certainly of eleven victories, this great commander had repelled the Saxons from the north of Flavia, dislodged them from all Maxima, and dispossessed them of all Valentia. And these were successes so unchequered with misfortunes, so great in themselves, and so beneficial to the public, that the name of Arthur claims the first rank in the list of military, and the better one of patriot, heroes." The twelfth battle of Arthur was fought in the south of England, after he was elected to the pendragonship, against Cerdic the Saxon. "This," says Mr Whittaker, "was a most extraordinary victory, and completes the circle of Arthur's military glories." In

the author's account of this prince's conduct in peace, he asserts, that "Arthur saw that an appointment was wanted, which should at once be a more regular and more honourable signature of merit—by the certainty of the honour and the greatness of the dignity, call out all the worth of all the worthy in the nation, and collect it round the throne of the pendragon. Accordingly he established a military order. It was the first that had ever been instituted in the island; and it has since been imitated by all the nations on the continent. By means of this association, Arthur raised among the provincials a general glow of ingenuous heroism, the first spirit of chivalry that ever appeared in Europe; that manly and honourable gallantry of soul, which has made him and his worthies the subject of romantic histories over all the west of it. By this, and this alone, could he have been what history represents him, the Revered Father of the British Heroes in general, even to the conclusion of the sixth century, and nearly the middle of the seventh. The order naturally survived its founder; and the members of it were denominated the Warriors of Arthur, though the persons were born half a century after his death."

Arthur's Seat, a high hill in the neighbourhood of Edinburgh, said to have been so denominated from a tradition that King Arthur surveyed the country from its summit, and also defeated the Saxons in its neighbourhood. It rises by a steep ascent, till it terminates in a rocky point about 810 feet high from the base. The traveller may here sit and survey at his ease the centre of the kingdom, besides having a complete view of Edinburgh, on which he looks down as if seated among the clouds. The whole forms a landscape sublime, various, and beautiful, in a very high degree.

ARTICLE, in *Grammar*, denotes a particle used in most languages for the declining of nouns, and denoting the several cases and genders thereof. The use of articles arises chiefly from this, that in languages which have no different terminations to express the different states and circumstances of nouns, there is something required to supply that office. The Latins have no articles; but the Greeks, and most of the modern languages, have had recourse to them, for fixing and ascertaining the vague signification of common and appellative names. The Greeks have their ὁ, the Italians their *il*, *lo*, and *la*; the French their *le*, *la*, and *les*; the Germans their *der*, *das*, *dat*. The English also have two articles, *a* and *the*, which being prefixed to substantives, apply their general signification to some particular things. Some grammarians make the article a distinct part of speech; others will have it a pronoun, and others a noun adjective. See Grammar.

ARTIFICER, a person who works in iron, brass, wood, &c. such as smiths, brasiers, carpenters, &c. The Roman artificers had their peculiar temples, where they assembled and chose their own patron to defend their causes; and they were exempted from all personal services. Taruntenus Paternus reckons 32 species of artificers, and Constantine 35, who enjoyed this privilege. The artificers were incorporated into divers colleges or companies, each of which had their tutelar gods, to whom they offered their worship. Several of these, when they quitted their profession, hung up their tools, a votive offering to their gods. Artificers were held a degree below merchants and *argentarii* or money-changers, and their employment more sordid. Some deny that in the earliest ages of the Roman state artificers were ranked in the number of citizens; others, who assert their citizenship, allow that they were held in contempt, as being unfit for war, and so poor that they could scarcely pay any taxes; for which reason they were not entered among the citizens in the censor's books; the design of the census being only to see what number of persons were yearly fit to bear arms and to pay taxes towards the support of the state. It may be added, that much of the artificers' business was done by slaves and foreigners, who left little for the Romans to mind but their husbandry and war.

ARTIFICIAL, in a general sense, denotes something made, fashioned, or produced by art, in contradistinction from the production of nature.

Artificial *Fire-works*. See Pyrotechny.

Artificial *Magnets*. See Magnets.

ARTILLERY.

The discovery of gunpowder by Roger Bacon in the thirteenth century, and of its application to military purposes by Schwartz in the fourteenth, caused a complete revolution in this branch of the art of war. The term *artillery*, previous to this discovery, denoted, in a general sense, all kinds of missiles, and the machines used in propelling them. Thus the artillery of the ancients consisted of the catapulta and balista, of darts, arrows, and other purely mechanical contrivances; while, at a later period, the Franks and their contemporaries used a species of small hatchet as a missile, discharging it at their enemies much in the same manner as the North American Indians do their tomahawks in the present day. However, the signification of the term changing with the advancement of science, we understand by it, in modern phraseology, guns, howitzers, and mortars, with their carriages, beds, ammunition, and apparatus of all kinds, and the troops specially appointed for their management.

In the rapid growth of scientific improvement which, during the last thirty-five years, has extended through every branch of our military establishment, there is nothing more remarkable or more honourable to our national ingenuity and energy than the changes which have been wrought in the organization of the ordnance service. These changes are such as to render the British artillery, from having been among the worst in Europe, absolutely the very finest and best—an example for the envy of the military powers of the Continent, and a model for the avowed imitation of even that nation which has heretofore been held to excel all others in the qualities of martial science. It has hitherto been admitted by universal consent, that, of all the people of Europe, the French have habitually, in their national character, shown most original genius and aptitude for military affairs; and it is therefore not a little gratifying to the British artillerist to observe these acknowledged masters of the art of war—these boasted instructors of our earlier years—surpassed in their own favourite vocation, and reduced to become in their turn the pupils and imitators of our military knowledge and invention.

This practical homage on the part of the French to the decided superiority of our artillery is a circumstance publicly and candidly admitted by some at least of their own writers. A memoir by the chef-de-bataillon Parizot, a skilful officer of the French artillery, details six essential advantages in the British system over that of his countrymen; and Dupin, who quotes this memoir, adds, in a note, the following testimony of a French general officer

who attended the review of the allied armies of occupation in France in 1818. "J'ai observé, avec beaucoup d'attention, les manœuvres d'artillerie des diverses puissances; j'ai été frappé de la beauté et da luxe de toutes les troupes qui composaient l'armée, de l'ordre et de la précision de leurs mouvemens et de leurs manœuvres; *mais les Anglais sont les premiers sous tous les rapports.*"[1]

All the improvements which have raised the British artillery to its present state of perfection are, as we have already said, the work of our own age. At the commencement of our share in the late war in 1793, the various ordnance equipments, as well as the whole composition of this branch of our military service, were of the rudest kind, and on the worst organized and most defective plan. The inefficiency of the whole system, indeed, was palpably betrayed whenever a force was required to take the field. The guns were dispersed among the infantry at the rate of two pieces to a battalion, thereby rendering it impracticable to employ them for their legitimate purpose—the concentrating a powerful fire of numerous guns on any important point. They were also horsed in single team, which needlessly both lengthened the column of march and diminished the power of draught. The drivers were on foot with long whips, as were also the gunners. The ammunition was packed in large rough deal boxes; the waggons which conveyed it were heavy and ill-constructed; and the whole equipment was so cumbrous, that it was impossible for the train to move out of a foot-pace, except for a very short distance; and if increased speed were attempted before the enemy, the men came into action breathless and unable to serve their guns.[2]

But before the commencement of the peninsular war, that active and able officer the late Major Spearman had entirely re-organized this branch of the service; and it is to him that the country owes the present beautiful system of field artillery. The battalion guns were abolished, and the artillery was brigaded, distinct from the infantry and cavalry with which it served, in divisions of six pieces each; so that the fire of one or more of these powerful batteries could be readily concentrated on any given point. A body of military drivers was organized, while, by an ingenious contrivance of the shafts, the power of using single draught in narrow roads, or when any of the horses were disabled, was retained. The drivers were mounted on the near horses; and the gunners themselves, in the proportion of eight to each piece, were carried on the limbers and ammunition cars. The whole of the equipment was simplified and lightened to such a degree that the batteries could move at a gallop; the ammunition, packed in boxes on the limbers and cars, was always up with the guns; and the officers and men, being all mounted or conveyed on the carriages, were sure of being brought fresh into action. Finally, a system of manœuvres for artillery in the field was introduced, which gave order and precision to their own movements, and established uniformity between them and the troops of other arms.[3] The advantages of this system are so ably described in the following observations of a general officer of the French artillery, who was present at the final review of the allied army of occupation in France, that we shall make no apology for introducing them in this place. "La cavalerie, soutenue par des masses d'infanterie, étant sur deux lignes, dans la plaine entre La Selle et l'Ecaillon, on vit à la fois se détacher des différens corps, plus de cent bouches à feu d'artillerie à pied et à cheval; et se porter, *avec la même vitesse*, à cent toises en avant de la première ligne de cavalerie. On commença l'affaire par une cannonade, qui ressemblait à un feu de file. Les mouvemens des batteries et les manœuvres des bouches à feu s'éxécutent avec beaucoup d'ordre et de précision. La facilité avec laquelle on met et ôte l'avant-train n'a pas échappé aux officiers d'artillerie. Il est survenu un accident à une batterie à pied qui arrivait au galop par un chemin très-escarpé. Ayant rencontré une calèche qui fermait le passage, elle n'hésita pas, dans la crainte d'un retard, à se précipiter dans le champ à gauche. Une seule pièce fut renversée, avec les cannoniers, dont un fut blessé. Elle fut relevée en un instant, et rejoignit sa batterie. Il y eut successivement deux charges de cavalerie par les deux lignes, qui, repoussées, vinrent se rallier l'une derrière l'autre. On vit les cannoniers, *emmenant les avant-trains*, abandonner les pièces, *et revenir aussitôt après la charge, recommencer le feu.* Le passage de l'Ecaillon, défendu par l'armée ennemie qui occupait les villages, les ponts, et tous les points importans de la position, donna lieu aux dispositions et aux manœuvres que nécessite une opération de cette importance. Le passage forcé, l'armée ennemie tournée par sa gauche, pressée par les alliés, fit sa retraite, défendant le terrain et les villages, pied à pied, jusque sur les hauteurs du camp de Famars. L'artillerie a suivi les mouvemens des divisions, dans la vallée difficile de l'Ecaillon, et dans la plaine au delà (malgré les obstacles) jusqu'au pied des hauteurs de Famars, arrivant sur le terrain en même temps que les troupes; cette position est couverte par un ravin profond et difficile, *qu'elle a franchi comme la cavalerie.* Quelques voitures ont versé, mais ont été promptement relevées. Notre artillerie n'aurait surmonté cet obstacle qu'avec beaucoup de temps et de travail."[4]

FIELD ARTILLERY.

When an army is to take the field, several considerations must be attended to in apportioning the number and calibre of the batteries to accompany it; as the face, features, and general nature, mountainous or otherwise, of the country which is to form the theatre of war,—the state of its roads, and the resources which it can supply for the means of transport,—the force and description of troops composing the army,—the nature of the war, whether offensive or defensive,—and, lastly, the intended plan of operations.[5]

In carrying on offensive operations in a champaign country, with good roads and facility of transport, the artillery should consist of 9-pounder batteries, to which a few 18 or 12-pounders should be added, to form on occasion batteries of position. There should likewise be one or more batteries of a lighter calibre, to accompany any corps of the army that may be destined by rapid marches to intercept the enemy's convoys or detachments.[6] In mountainous or deep hilly countries, the artillery should not be composed of heavier ordnance than the 6-pounder battery; but an exact topographical acquaintance with the nature of the country is absolutely necessary, and indeed affords the only satisfactory guide for judging of the most appropriate calibres to be employed. When an army is to remain on the defensive in a country where the roads are only tolerable, and the probability of being obliged to undertake long and rapid marches is not great, the artillery should be composed of a heavier description of batteries

[1] *Force Militaire de la Grande Bretagne.*
[2] *British Gunner.*
[3] *Ibid.*
[4] *Force Militaire de la Grande Bretagne.*
[5] *Traité Elémentaire d'Artillerie.*
[6] D'Antoni.

Field Artillery.

than would be proper to accompany an army acting offensively in the same country. But if this defensive system be carried on in a strong country, where the means of transport are attended with difficulty, and long and rapid marches may become indispensably necessary, the batteries must be so constituted as to adapt them to these several circumstances, otherwise the artillery will retard the army in its operations, instead of contributing to the attainment of the object in view.[1]

The annexed table exhibits the composition of each kind of field battery, and the proportion of ammunition and laboratory stores carried with each piece of ordnance.

Nature of Battery, Ammunition, and Laboratory Stores.	12-Pounders.	9-Pounders.	6-Pounders, Heavy.	6-Pounders, Light.	3-Pounders, Heavy.	24-Pounders, Howitzers.	12-Pounders, Howitzers.	Ammunition Cars.	Store Carts.	Store Waggons.	Forge Waggons.	Spare Carriages.
12-Pounder	5					1		12	1	2	1	1
9-ditto		5				1		9	1	1	1	1
6-ditto, heavy			5			1		8	1	1	1	1
6-ditto, light				5			1	8	1	1	1	1
3-ditto, heavy					5		1	7	1	1	1	1
Shot — Round	114	114	174	171	272							
Shot — Case — Common	14	19	22	20	44	12	12					
Shot — Case — Spherical	50	30	34	29		72	116					
Shells, common, empty						56	84					
Carcasses, round, fixed						4	8					
Flannel Cartridges, filled — 4 lbs	98											
Flannel Cartridges, filled — 3 lbs		126										
Flannel Cartridges, filled — $2\frac{1}{2}$ lbs						84						
Flannel Cartridges, filled — 2 lbs			200									
Flannel Cartridges, filled — $1\frac{1}{2}$ lbs				194								
Flannel Cartridges, filled — $1\frac{1}{4}$ lbs							128					
Flannel Cartridges, filled — 1 lbs					316							
Quick-Match, Yards	10	10	10	10	10	10	10					
Tubes	200	200	300	300	400	200	200					
Fuses — Spherical — Cut — 4 tenths	28	24	30	26		42	68					
Fuses — Spherical — Cut — 6 ditto	28	24	30	26		42	68					
Fuses — Spherical — Cut — 8 ditto	28	24	30	26		42	68					
Fuses — Spherical — Uncut	28	24	30	26		42	68					
Fuses — Common, graduated						40	60					
Slow-Match, Skeins	3	3	3	3	3	3	3					

The following is the distribution of the above proportion of ammunition in the limber and ammunition boxes of field guns and howitzers, together with the distribution in the reserve waggons of the additional proportion judged necessary to accompany each battery in the field.

12-*Pounders* (*medium*).

Distribution of Ammunition.	Nature of Ammunition. Round Shot.	Case. Common.	Case. Spherical.	Total of Rounds.
Gun limber, 2 boxes	6	6	6	18
Waggon — Limber, 2 boxes	18	4	16	32
Waggon — Body — Fore box	18		6	24
Waggon — Body — Hind box	18		6	24
Total with the gun and waggon	60	10	28	98
Reserve waggon	54	4	22	80
Total per gun	114	14	50	178

Ten waggons per battery of five guns, carrying 178 rounds of ammunition per gun.

9-*Pounders*.

Distribution of Ammunition.	Nature of Ammunition. Round Shot.	Case. Common.	Case. Spherical.	Total of Rounds.
Gun limber, 2 boxes	16	8	8	32
Waggon — Limber, 2 boxes	16	8	8	32
Waggon — Body — Fore box	22		8	30
Waggon — Body — Hind box	32			32
Total with the gun and waggon	86	16	24	126
Reserve — Two waggons for the 5 guns (Rd. 140, Com. 16, Sph. 32, Total 188) per gun	28	3	6	37
Total per gun	114	19	30	163

Seven waggons per battery of five guns, carrying 163 rounds of ammunition per gun.

[1] *British Gunner.*

6-*Pounders (heavy).*

Distribution of Ammunition.	Nature of Ammunition. Round Shot.	Case. Common.	Case. Spherical.	Total of Rounds.
Gun limber, 2 boxes	30	10	10	50
Waggon: Limber, 2 boxes	30	10	10	50
Waggon: Body: Fore box	40		10	50
Waggon: Body: Hind box	50			50
Total with the gun and waggon	150	20	30	200
Reserve: One waggon for the 5 guns. Rd. Com. Sph. Total 120 10 20 150 per gun	24	2	4	30
Total per gun	174	22	34	230

Six waggons per battery of five guns, carrying 230 rounds of ammunition per gun.

6-*Pounders (light).*

Distribution of Ammunition.	Nature of Ammunition. Round Shot.	Case. Common.	Case. Spherical.	Total of Rounds.
Gun: Axle-tree, 1 box	3	3		6
Gun: Limber, 2 boxes	24	8	8	40
Waggon: Limber, 2 boxes	32	8	8	48
Waggon: Body: Fore box	40		10	50
Waggon: Body: Hind box	50			50
Total with gun and waggon	149	19	26	194
Reserve: One waggon for the 5 guns. Rd. Com. Sph. Total 114 8 18 140 per gun	22	1	3	25
Total per gun	171	20	29	220

Six waggons per battery of five guns, carrying 220 rounds of ammunition per gun.

3-*Pounders (heavy.)*

Distribution of Ammunition.	Nature of Ammunition. Round Shot.	Case.	Total of Rounds.
Gun: Axle-tree, 1 box	4	4	8
Gun: Limber, 2 boxes	50	20	70
Waggon: Limber, 2 boxes	50	20	70
Waggon: Body: Fore box	84		84
Waggon: Body: Hind box	84		84
Total per gun	272	44	316

No reserve waggons. Three hundred and sixteen rounds of ammunition per gun.

24-*Pounder Howitzer.*

Distribution of Ammunition.	Nature of Ammunition. Shells.	Case. Common.	Case. Spherical	Carcasses.	Total of Rounds.
Howitzer, limber, 2 boxes	8	4	12		24
Waggon: Limber, 2 boxes	8	4	12		24
Waggon: Body: Fore box	8		8	2	18
Waggon: Body: Hind box	8		10		18
Total with howitzer and waggon	32	8	42	2	84
Reserve waggon	24	4	30	2	60
Total per howitzer	56	12	72	4	144

Two waggons to each howitzer, carrying 144 rounds of ammunition.

12-*Pounder Howitzer.*

Distribution of Ammunition.	Nature of Ammunition. Shells.	Case. Common.	Case. Spherical.	Carcasses.	Total of Rounds.
Howitzer, limber, 2 boxes	12	4	20		36
Waggon: Limber, 2 boxes	12	4	20		36
Waggon: Body: Fore box	12		12	2	28
Waggon: Body: Hind box	12		16		28
Total with howitzer and waggon	48	8	68	4	128
Reserve waggon	36	4	48	4	92
Total per howitzer	84	12	116	8	220

Two waggons to each howitzer carrying 220 rounds of ammunition per howitzer.

The flannel cartridges and small stores are distributed in the several boxes in equal proportion with the other ammunition, according to circumstances.

The following historical examples of the relative proportions of artillery acting with various armies in different countries during the late war, may, with the assistance of good topographical maps, enable an officer to form a tolerably accurate judgment on this important branch of military study.

The Austrian army, under the command of the archduke Charles in the campaign of Aspergne, Essling, and Wagram, consisted of about 75,000 men, to whom were attached 18 batteries of brigade, 13 of position, and 11 of horse-artillery; being in the proportion of one piece of ordnance to 260 men nearly.

The allied British and Portuguese army in the field in Spain, May 1813, consisted of 65,000 men and 102 pieces of artillery, including the reserve; being in the proportion of one piece of ordnance to 622 men nearly.

The grand French army under Napoleon, for the invasion of Russia, not including the Austrian contingent, consisted of 400,000 infantry, 60,000 cavalry, and 1200 pieces of artillery; being one piece of ordnance to 383 men.

The French armies united on the Tormes in December 1812 amounted to 80,000 men and 200 pieces of artillery, being in the proportion of one gun to 400 men.

Field Artillery.

Napoleon in 1813 had 1400 pieces of artillery to 300,000 men, or one gun to 200 nearly. In 1815 his army consisted, as nearly as can be ascertained, by a comparison of several accounts of the campaign, of 130,000 infantry, 20,000 cavalry, and 300 pieces of artillery; being one piece of ordnance to 500 men.

The Prussian contingent of the grand French army for the invasion of Russia, under the command of General D'York, consisted of 20,000 men and 60 pieces of artillery; being in the proportion of one piece of ordnance to 333 men nearly.

Marshal Beresford, at the battle of Albuera, had 29,000 men and 32 pieces of artillery, or one gun to 900 men. His opponent Marshal Soult, in the same action, had 23,000 men and 40 pieces of artillery, or one gun to 575 men.

General L'Espinasse, who commanded the artillery of Buonaparte in Italy, supposes a division of an army to consist of 12,000 men, including a regiment of dragoons and another of hussars, to which he allots three batteries of horse and three of field artillery, each consisting of six pieces of ordnance. A battery of horse and another of field artillery are at all times to be up with the army; two batteries, similarly armed with the two in activity, are to remain with the park; and the remaining two, also appointed in like manner, should be in depôt in rear of the army. These proportions of artillery to infantry, L'Espinasse states, are precisely those adopted with the approbation of Buonaparte in the Italian campaigns.[1]

Positions and Movements of Field Artillery.

The commanding officer of artillery, in order that he may choose proper positions for his field batteries, should be made acquainted with the effect intended to be produced, with the troops that are to be supported, and with the points to be attacked, that he may place his artillery so as to support, but not incommode the infantry, nor take up such situations with his guns as would be more advantageously occupied by the line; that he may not place his batteries too soon, nor in exposed situations; that he may cover his fronts and flanks by taking advantage of the ground; and that he may not venture too far out of the protection of the army, unless some very decided effect is to be obtained by so doing.

In a defensive position the guns of the largest calibre should be posted on those points from whence the enemy can be discovered at the greatest distance, and from whence may be seen the whole extent of his front. In an offensive position, the weakest points of the line, and those most distant from the enemy, must be strengthened by the largest calibres. Those heights on which the army, in advancing, may rest its flanks, must be secured by them, as also those from which the enemy may be fired upon obliquely.

Artillery should never be placed in such a situation that it can be taken by any enemy's battery obliquely, in flank, or in reverse, unless a position under these circumstances offers every prospect of producing a most decisive effect before the guns can be destroyed, or placed *hors de combat*. The most elevated positions are not the best for artillery; the greatest effects may be produced from a height of from 30 to 40 yards at the distance of 600, and from about 16 yards high at 200 yards distant. Those positions which are not likely to be shifted, but from whence an effect may be produced during the whole of an action, are to be preferred, and in such positions breast-works of two or three feet high should be thrown up to cover the carriages.

The guns must be so placed as to produce a cross-fire upon the enemy's position, and upon the ground over which he must pass to attack you. It may sometimes be necessary, in order to concentrate a cross-fire on one particular point, to subdivide your batteries. Thus, his fire may be attracted to different objects whilst your own is directed to a focus, which may be the *débouché* of the enemy, the head of his advancing columns, or the ground in front of the weakest point in your own line. If the enemy's position is to be attacked, your fire must become direct in proportion as the troops advance, otherwise it will impede them; and when you can no longer fire on the point attacked, the guns must be directed on the collateral points.

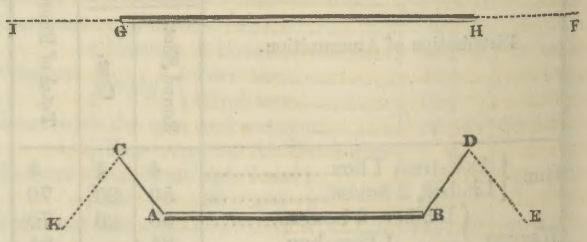
The guns should be placed as much as possible under cover. This is easily done upon heights, by keeping them so far back as that only the muzzles may be perceived over them. With proper attention, many situations may be found of which advantage may be taken for this purpose, such as banks, ditches, &c. everywhere to be met with. If an enemy's attack is expected, the guns must be posted so as to cannonade him with effect when he advances within 800 paces, and particularly in situations in which his march may be retarded by ditches, defiles, or other natural obstacles.

The position from whence the enemy is to be cannonaded should be kept concealed from him till the moment the batteries are to open. To effect this, the guns may until that time be placed in any other situation. Should there be any small elevations of earth in front of a defile through which the enemy may advance and be cannonaded, the guns must be kept under cover of them until he comes out and begins to form. The guns may also be masked by being covered by troops, particularly cavalry, until the enemy is within the range of case-shot. The covering party must then open right and left, and a brisk fire be kept up.

Artillery should very rarely be placed in front of a line of infantry, or distributed by batteries in the intervals. When the line is of great extent, it may become necessary to place a strong battery in the centre. This should be composed of the guns of the heaviest calibre; and it should be posted in the interval between the right and left wings of the army, by which means a double object is not offered to the enemy's fire. In general, an army in order of battle may be considered as a front of fortification, the infantry forming the curtain, and the lateral batteries the bastions, under the fire of which the troops may manœuvre freely, and advance with confidence to attack the enemy.

The two following examples will serve to illustrate the preceding remarks:—

Battle of Castiglione, 5th August 1796.—The following diagram shows the disposition of the French under Buonaparte, and the imperialists under Wurmser, in this battle:

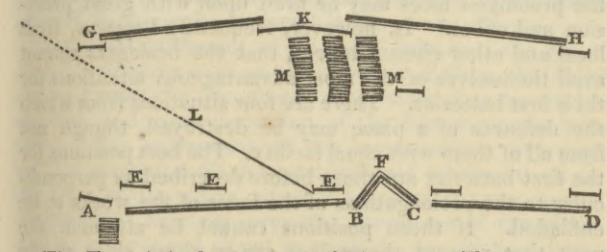


A B the French army, G H the imperial army, A C a battery of 12 pieces of foot artillery, sustaining the left of the French on the heights in advance of Castiglione; B D

[1] *Essai sur l'Artillerie*, par le Général L'Espinasse.

a battery of 20 pieces of light artillery appuying on the right, which extended into the plain. The line of infantry A B being taken for the curtain, the batteries A C and B D may be considered as representing the faces of two bastions, thus forming a complete front, and crossing their fire before the curtain. The troops are consequently covered from attack, and the enemy fired upon obliquely. Wurmser having prolonged his front from G to I with the intention of outflanking the French, General L'Espinasse took some of the guns from C A, and placed them on the other face C K, until others could be drawn from the park for that purpose, thus forming a new battery destined to follow the enemy's movements. Another battery was likewise formed on the right, from D to E, in case Wurmser had prolonged his left from H to F.

Battle of Talavera, 27th and 28th July 1809.—At the commencement of the battle the British artillery were stationed, by batteries of six guns each, with the divisions of the army to which they were respectively attached; a temporary redoubt, unfinished, was thrown up at F, in which a battery of 3-pounders was posted; on the hill, at A, the most commanding point of the position, two batteries were posted, one of heavy 6-pounders, the other of light sixes, to which two Spanish guns were afterwards added.



The French had a battery of 14 guns at K, the centre of their position, also one at each of the flanks G and H, independently of others which were brought up during the action. On the second day, when the columns at M advanced, supported by artillery, to attack the British right, which rested on the unfinished redoubt, the three batteries E E E were formed on the oblique line L E, and thus took the advancing columns in flank, whilst the redoubt kept up a direct fire in their front.

It must here be observed, that whenever an oblique line is formed by artillery, as from L to E, it must be directed without the extremity of the enemy's flank, otherwise the guns will be exposed to his enfilading fire.

SIEGE ARTILLERY.

The first duty of the commanding officer of artillery, when it is intended to besiege a fortress, is to prepare an estimate of the quantity of ordnance and ammunition required for its reduction. To enable him to make this estimate with accuracy and precision, he should be master of certain data; that is to say, the commander of the forces, or general charged with the direction of the siege, should communicate to him a plan of the fortifications and environs of the place, accompanied by such profiles and remarks as may enable him, in conjunction with the commanding engineer, to ascertain which front or fronts are most assailable, with the advantages and disadvantages attending each attack, as well with respect to the works of the place, as to the nature of the soil where the trenches must be opened, and the several heights and hollows in the vicinity.[1] He should also, if possible, be informed as to whether the place be amply supplied with artillery, ammunition, &c.; if the garrison be sufficiently numerous, and whether composed of veteran troops or raw levies; if the governor be in high estimation for his military talents; if the town be populous, and the inhabitants well affected to the garrison.[2] It will thus be easy to form a tolerably accurate opinion of the means of defence, and the resistance to be expected; for it is not to be presumed that any government would shut up a brave and numerous force in an ill-fortified and badly provisioned place, at the risk of seeing such a garrison sacrificed after a short resistance.

But should it be impossible to procure information on these several points beforehand, particularly as to the strength of the garrison, the requisite proportion of ordnance and ammunition must be regulated on the general principles of attack. The officer intrusted to prepare the estimate must, therefore, endeavour to ascertain, according to the fundamental maxim of all besiegers, against which front or fronts the attack can be made with the least exposure and greatest expedition. He should examine whether the siege can be most advantageously carried on by regular approaches; by taking advantage of any defect in the situation which may enable him to break ground close to the works to be breached; or by battering them from a distance. By the aid of this investigation, and the following general principles, the quantity of ordnance and ammunition required for the siege of a place may be ascertained with the greatest accuracy.

General Principles for the Attack of Fortified Places.

1. The number of batteries to be opened against the defences must depend upon the extent of the works to be embraced by the attack, *i. e.* there must be a battery to enfilade every face that can in any way annoy or retard the besiegers in their approaches.

2. The length of the epaulement of these batteries need not exceed the breadth of the terreplein of the works to be enfiladed, unless circumstances should render it necessary to place some of the guns in a situation to take the work in reverse. Each battery will only contain, therefore, five, or at most eight guns, to enfilade the face of the principal work; to which must be added two others to enfilade the branches of the opposite covered-way.

3. The situation of the breaching batteries must be determined, as, in a regular attack, they sometimes interfere with the fire of the first or enfilading batteries. Should this be the case, the same artillery must be transferred from one battery to the other.

4. The supply of ordnance must be sufficiently liberal to enable the besiegers to keep up a fire constantly superior to that of the place. This supply is determined by the extent of the fortifications of the place; one piece of ordnance must be allowed for every twelve or fifteen feet.

5. As the *ricochet* firing may be interrupted while the sappers are completing the third parallel, a supply of royal and cœhorn mortars must be provided to harass the garrison from the second parallel, or demi-places of arms, during its cessation.[3]

Having thus ascertained the number of guns required, the following will be their calibres, and the proportions which the remaining ordnance should bear to them.

Guns—of the whole number required—suppose 60.
24-pounders.....$\frac{2}{3}$ or 40
12-pounders.....$\frac{1}{3}$ or 20
Howitzers—one for every four guns—in this case 15.
10-inch.....$\frac{1}{3}$ or 5
8-inch.....$\frac{2}{3}$ or 10

[1] *Traité Elémentaire d'Artillerie.* [2] *British Gunner.* [3] *Ibid.*

Mortars—in the proportion of one-twelfth more than the number of guns—in this case 65.

10-inch.....$\frac{2}{13}$ or 10
8-inch.....$\frac{3}{13}$ or 15
Royal.....$\frac{4}{13}$ or 20
Cœhorn.....$\frac{4}{14}$ or 20

In the above proportion of ordnance, it must be observed that the long 12-pounder is proposed instead of the 18-pounder formerly employed, as a gun of this description is conceived to be sufficiently powerful for annoyance and direct fire, to dismount the enemy's artillery, as well as for firing *en ricochet.* The diminished weight of ammunition attendant on the employment of the smaller calibre is an important advantage; but it is an arrangement which can only be admitted in cases where an adequate number of 24-pounders are provided. In all smaller equipments it would, therefore, be better that all the guns should be of the heavy calibre.[1]

The proportion of small mortars should in no case be less than that of the heavy mortars and howitzers, and this proportion ought to be increased in all equipments of less than thirty pieces of ordnance: indeed, when sent at all, there should be at least twelve of them, to insure the necessary effect: in many cases a far greater number than is here proposed could be advantageously used, but this must of course depend on the nature of the service on which they are likely to be employed. The royal and cœhorn mortars have in the present instance been taken in equal proportions, and it would be advisable to adhere to this arrangement in all the larger equipments, particularly when their calibres correspond with those of the guns; but in small equipments it would be more convenient to confine the arrangement to one calibre, in which case the royal mortar is the preferable, as it possesses the power of being used at a greater distance than the cœhorn. But it must at the same time be observed, that the latter, from its lightness and the small weight of its ammunition, is a more desirable implement for the more advanced parts of the attack.

The quantity and relative calibres of the ordnance being determined, the following will be the proportion and nature of ammunition.

Gun ammunition.—Round shot,
24-pounder.....1000 rounds per gun.
12-pounder.....1200 rounds per gun.
Tier shot..... 50 rounds per gun.
Spherical case..... 100 rounds per gun.
Howitzer ammunition.—Shells,
10-inch.....600 rounds per howitzer.
8-inch.....300 rounds per howitzer.
Spherical case,
8-inch.....300 rounds per howitzer.
Carcasses..... 10 rounds per howitzer.
Valenciennes composition,
10-inch.....100 proportions per howitzer.
Mortar ammunition.—Shells,
10-inch.....600 per mortar.
8-inch.....600 per mortar.
Pound shot,
10-inch...50 rounds of 100 shot each per mortar.
Carcasses,
10-inch.....10 per mortar.
8-inch.....10 per mortar.
Valenciennes composition,
10-inch.....100 proportions per mortar.

In the above proportion of ammunition there is an increase of two hundred rounds in favour of the 12-pounders, as the facility of working these guns will, at an easy rate, afford the means of firing more rapidly than from 24-pounders. The proportion of one half common shells and one half spherical case should always be adhered to for the 8-inch howitzers.

Arrangement of Artillery at a Siege.

The first disposition of the artillery at a siege is to the different batteries raised near the first parallel. The object of the besieger in the construction of these batteries is, by a direct and enfilade fire, to dismount the artillery on the front attacked, destroy the embrazures, and harass the garrison in the several points of defence, so that they may be compelled to abandon them, or at least slacken their fire, and thereby enable the besieger to carry forward his approaches with greater expedition and less danger than he otherwise could do.[2] If these first batteries be favourably situated, the artillery may be continued in them during the whole of the siege, or until the besiegers arrive on the crest of the glacis. The garrison must be perpetually harassed along the whole front attacked, with shot and shells fired *en ricochet.* The batteries for this purpose are erected on the prolongations of the works to be enfiladed, from whence the defenders of the prolonged faces may be fired upon with great precision and effect.[3] It, however, frequently happens, from local and other circumstances, that the besiegers cannot avail themselves of the most advantageous situations for their first batteries. There are four situations from which the defences of a place may be destroyed, though not from all of them with equal facility. The best positions for the first batteries are those before described as perpendicular to the prolongations of the faces of the works to be enfiladed. If these positions cannot be attained, the next that present themselves are on those sides of the prolongations which take the faces in reverse, and under as small angles as possible. If the ground or other circumstances will not admit of either of these situations being occupied by enfilading batteries, the battery to destroy the fire of the face must be without its prolongation, so as to fire obliquely upon the outside of it: the fourth position in point of advantage is directly parallel to the face. The guns must fire *en ricochet* from the first two positions, and from the last two with full charges.

The second batteries are generally placed on the glacis, within fifteen or eighteen feet of its crest; but if the foot of the revetment cannot be seen from this situation, they must be placed in the covered-way, within fifteen feet of the counterscarp.[4] The object of these second batteries being to effect practicable breaches in the works, they should be combined, two and two together, so that while one batters in breach, the other may play upon its defences. The breaching batteries shall commence by marking out as nearly as possible, by their fire, the extent of the breach intended to be made; first, by striking out a horizontal line as near as possible to the bottom of the revetment; and next, by aiming at two others, perpendicular to and at the extremities of this first line. Then, by continuing to deepen these three cuts, and occasionally firing salvoes at the part to be brought down, the wall will in time give way in a mass. The guns must begin by firing as low as possible in the commencement of the operation, afterwards somewhat higher in the same manner as before, and so continue advancing gradually upwards till the breach is effected; for, should they fire too high at first, the rubbish would cover the lower part of the wall, retard the operation, and tend to render the

[1] *British Gunner.*
[2] *Essai Générale de Fortification.*
[3] *British Gunner.*
[4] *Traite d'Artillerie,* par D'Antoni; *British Gunner.*

breach impracticable. When the second batteries are placed on the glacis, or in the covered-way, they must be sunk to such a depth that the terreplein of the one, or surface of the other, may coincide with the soles of their embrazures. They are in fact but an enlargement of the sap run for the lodgement on the glacis, or in the covered-way, and should contain at least four guns each. If the space between the traverses will not admit of this number at the usual distances, the guns must be closed from twelve to fifteen feet of each other.

The mortars are generally arranged at first in battery, adjoining the first gun batteries, or upon the prolongations of the capitals of the works, in which situations they are certainly least exposed; and upon the establishment of the half parallels the howitzers are placed in battery, in their extremities, to enfilade the branches of the covered-way. These batteries are in the most advantageous situations, if, while the one bombards the work that the besieger intends to assault, and prevents the garrison from throwing up intrenchments within it, or at least retards their construction, the other directs its fire against the defences of the breach, so that the garrison may, from the continual shower of shells, &c. be compelled to abandon them, or, if they persist in remaining, be exposed to great loss. The small mortars are arranged in the third parallel, to annoy the besieged in the places of arms.

In the establishment of all these batteries, the great object is to make such an arrangement of them, that they may not mask the fire of each other more than cannot be avoided, and particularly that of the first or *ricochet* batteries. The aggravation of this inconvenience may very well be prevented till the establishment of the attack on the crest of the glacis, when it becomes in some degree unavoidable: however, even the operations of the glacis may be so arranged as not to mask the fire of the *ricochet* batteries, until the breaching batteries are in a state of great forwardness.

GARRISON ARTILLERY.

The proportion of ordnance, ammunition, and stores required for the defence of a fortified place depends not only on the particular situation of each individual fortress, and its relations with the surrounding country; the system according to which it is fortified, and the species of attack it may be possible to open against it; but likewise on innumerable minor circumstances, each of which may exert an important influence on the defence. If, for example, one or more of the fronts of a place be covered by an inundation, a marsh, or by any other impassable obstacle, it will manifestly require a much smaller proportion of artillery for its defence than if it were equally accessible on every front. On the contrary, a maritime fortress, which is susceptible of attack both by sea and land, will require a larger proportion of ordnance supplies than if it were assailable from only one of these points.[1]

It will be seen, therefore, from the above remarks and examples, how impossible it is to lay down any general rules upon this important subject. The only satisfactory guide which an officer charged with the nice and responsible trust of arming a fortified place can with security follow, is to examine attentively all parts of the works and of the surrounding country, and then to weigh every other circumstance that can in any way influence the defence. He should consider which of its fronts are most vulnerable, and what measures are best adapted for their security. To effect this with accuracy and expedition, he should, after a few days passed in reconnoitring and studying his position, devote his attention to the preparation of a sketch and profiles of the works and neighbouring country, as far at least as a mile in every direction, and upon a scale adapted to the features of the ground.

With this map and profiles before him, he should recur to those fundamental principles upon which every good attack and defence are based. He should not only be thoroughly acquainted with his own particular branch of the service in all its details, but capable of judging to the fullest extent of all operations in which the other troops of the garrison can bear their part; so that every supply may be adequate to its particular purpose, without deficiency on the one hand or superfluity on the other. Thus two extremes, equally prejudicial, will be avoided; the one, of making a provision insufficient for the defence which the fortress is capable of sustaining; the other, of providing such a quantity of supplies, that, on its capitulation, which, according to the natural order of things, must sooner or later happen, if it be not relieved, a complete arsenal would fall into the enemy's hands.[2]

These observations being held in mind, the following general maxims will be found of essential assistance.

General Maxims for arming Fortified Places.

1. The proportion of ordnance, ammunition, and stores should never exceed the quantity absolutely necessary to a brave and resolute defence.

2. Those fronts which are considered susceptible of attack should be completely armed, and the remaining fronts only in part.

3. These should be, for each of the faces of the bastions of such fronts as are deemed liable to attack, five or six pieces of ordnance; for each of the flanks of these bastions four pieces; and for the faces of the ravelin from five to seven pieces of ordnance. When these are lunettes, four pieces should be reckoned for each, and from two to three for each of the places of arms of the covered-way. Supposing, therefore, one front to be completely armed, the following proportion of ordnance will be required.

The faces of the two bastions	from 10 to 12
two interior flanks	from 6 to 8
faces of the ravelin	from 5 to 7
five places of arms	from 10 to 15

making a total for one front of from 33 to 42 pieces of ordnance.

4. In case of the place being liable to attack on two consecutive fronts, the above proportion should be augmented one half; and if on two detached fronts, it should be doubled. The remaining fronts should each be provided with such a proportion of their full armaments as will secure them from insult. It will appear from the above maxims, which are deduced from the best authorities on the subject, that a hexagon, having only one front exposed to attack, requires an armament of from 58 to 68 pieces of ordnance for its defence; and that for more extensive places, from six to eight, or at most ten pieces of ordnance, should be added for each additional front.[3]

The next point to be considered is the proportion which the several kinds of ordnance, and their relative calibres, should bear to each other; and here it must be remembered that the higher rates are not the only descriptions capable of being employed to advantage in the defence of a place. There are many cases in which medium guns can oppose equal resistance with the heavier calibres, and

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[1] *British Gunner.*

[2] *Traité Elémentaire d'Artillerie.*

[3] *Manuel de l'Artilleur; Traité d'Artillerie*, par D'Antoni.

Garrison Artillery.

they possess the very important advantage of affording greater facility in manœuvring and transporting them from one situation to another; an operation of considerable difficulty with the higher natures of ordnance at all times, but particularly during a siege. They also consume less ammunition, and enable the besieged to keep up a more determined and incessant fire.[1]

The following are the proportions of the several kinds and calibres usually adhered to in ordinary cases.

Guns—in the proportion of two thirds of the whole armament—suppose 60.

24-pounders.....$\frac{1}{10}$ or 6
18-pounders.....$\frac{2}{10}$ or 12
12-pounders.....$\frac{3}{10}$ or 18
9-pounders.....$\frac{4}{10}$ or 24

Howitzers—one for every five guns—in this case 14.

10-inch.....$\frac{1}{2}$ or 7
8-inch.....$\frac{1}{2}$ or 7

Mortars—in about the same proportion as the howitzers—in this case 16.

10-inch.....$\frac{1}{2}$ or 8
8-inch.....$\frac{1}{2}$ or 8

The above distribution of guns, howitzers, and mortars, applies equally to all armaments of not less than sixty pieces of ordnance; and such an armament should therefore consist of forty guns, eight howitzers, and twelve mortars. The proportions of the several calibres of each kind, except those for the guns, are calculated on a basis of not less than ninety pieces of ordnance; and in all smaller armaments it would be advisable to confine the arrangement to two calibres of each kind only.

The following will be the proportion and nature of ammunition for each species of ordnance.

Gun ammunition.—Round shot,

24-pounder..... 600 rounds per gun.
18-pounder..... 760 rounds per gun.
12-pounder..... 800 rounds per gun.
9-pounder.....1000 rounds per gun.

Case shot,

24-pounder..... 40 rounds per gun.
18-pounder..... 50 rounds per gun.
12-pounder..... 80 rounds per gun.
9-pounder.....100 rounds per gun.

Spherical case,

24-pounder..... 50 rounds per gun.
18-pounder..... 80 rounds per gun.
12-pounder.....100 rounds per gun.
9-pounder.....150 rounds per gun.

Howitzer ammunition.—Shells,

10-inch.....400 rounds per howitzer.
8-inch.....600 rounds per howitzer.

Case shot,

10-inch.....100 rounds per howitzer.
8-inch.....250 rounds per howitzer.

Spherical case,

8-inch.....500 rounds per howitzer.

Light balls and carcasses,

8-inch.....20 rounds of each per howitzer.

Mortar ammunition.—Shells,

10-inch.....500 rounds per mortar.
8-inch.....650 rounds per mortar.

Pound shot,

10-inch.....500 rounds per mortar.
8-inch.....600 rounds per mortar.

Each round of pound shot consists of 100 shot for the 10-inch, and of 80 for the 8-inch mortar.

Light balls..... ..15 per mortar.

The above proportion of ordnance and ammunition for the defence of a fortified place is exclusive of one or more field batteries, which every place should contain, according to its extent, and which should be provided with a double proportion of ammunition. (See the preceding section on FIELD ARTILLERY.)

This estimate and arrangement is founded upon the supposition that the place is unprovided with casemated batteries, the armament for which must of course form a separate estimate, calculated, however, upon the same principles as the above.

Arrangement of the Artillery during a Siege.

The instant it is ascertained that the enemy's troops are in motion towards the place,—presuming that it is amply supplied with provisions, ammunition, and stores, and that every precaution has been taken to collect from the vicinity what might fall into the enemy's hands,—the barbette batteries must be established in the flanked angles of the bastions and ravelins, and a proportion of the light guns and howitzers must be placed in the outworks and covered-way. Should the body of the place have cavaliers, the heaviest guns should be mounted on them. The following arrangement is usually made for the reception of the investing corps, when it is not known from what point they may advance to commence operations.

There should be three guns mounted on the barbette of each bastion,—one 24 and two 18-pounders, and three 9-pounders on the barbette of each of the ravelins. In the salient places of arms of the bastions one 24-pounder howitzer, and in those of the ravelins two 6-pounders. The heavy mortars should be placed one in each bastion, and the remainder of the ordnance in reserve behind the curtains, ready to move on whichever side it may be required.

By this arrangement the whole of the barbette guns, and of the guns and howitzers in the outworks and covered-way, will be in readiness to act in any direction, till it is known on which side the enemy has determined to direct his attack, and, with the addition of the reserve, will enable the besieged to open a fire of thirty-five pieces of ordnance on the enemy the very first night he begins to work upon the trenches. In the first moments of the investment, however, the artillery of the place should not endeavour, by a useless expenditure of ammunition, to disturb the besiegers in their operations: it is only when they are making permanent dispositions for their establishment that the fire of the place should be opened upon them. It is nevertheless necessary that some guns should be loaded with reduced charges, to protect the retreat of the advanced posts, and mislead the enemy as to their range. This is also the moment, if the garrison be numerous, and composed of good troops, to annoy the besiegers, by sorties on different points of the line of contravallation, and to retard the works necessary for establishing their communications: care must, however, be taken not to purchase this advantage by a loss of men and artillery, which would cripple the means of defence.

The day succeeding the night on which the trenches are opened, and the front of attack determined, a new disposition of the artillery of the place must be made as follows:—

The 24 and 18-pounders must be removed to the front attacked, and the other batteries, if necessary, supplied with 12-pounders. The barbettes of the bastions on this front must have each five guns, three 24 and two 18-pounders, and the remaining 18-pounders arranged behind the curtains,—two towards each of the extremities

[1] *British Gunner.*

Exercises. of the front curtain, and two at the farthest extremity of each of the collateral curtains. The howitzers in reserve should be placed, two in each of the salient angles of the covered-way of the bastions of this front, and two in each of those of the collateral bastions, which, with those already there, must fire *en ricochet* down the prolongations of the capitals. There should also be three 6-pounders in the salient place of arms of the ravelin of the front attacked, and three in each of those of the two collateral ravelins; these guns should fire over the palisading: and, lastly, there should be five 9-pounders on the barbette of the front ravelin. This arrangement will bring fifty-two guns and howitzers and four mortars to fire on the approaches, after the first night. This, with a few variations, will be the disposition of the artillery of the place till the besiegers' first batteries are ready to open. The instant they begin to work upon these batteries, the whole fire of the place must be concentrated on them, and the mortars which had previously fired at low angles must now fire with greater elevation, but at all times sparingly.

As soon as the enemy's batteries are fairly established, the guns *en barbette* must be covered by merlons, and the embrazures occasionally masked. While this work is carrying on, the situations of the guns should be changed, and new directions given to them; as by frequently practising this manœuvre, the enemy will also be obliged to change his dispositions of attack, and time will thereby be gained by the besieged. As the enemy approaches towards the second parallel, the fire of the place must be spread over all parts of his line of operations; and with a view of contributing to this object, royal and cœhorn mortars should be disposed in the places of arms and branches of the covered-way. When the approaches are carried on from the second parallel, and the enemy is about to establish the demi-places of arms, the fire of the place must be concentrated on the *débouchés* from the parallel, and multiplied with all possible activity.

In proportion as the besieger pushes forward his approaches to the third parallel, the artillery must be withdrawn from the covered-way to the ravelins, or to the ditch, if dry, or to any other favourable situation, and by degrees, as they advance, to the body of the place. During this period of the siege the embrazures must be prepared in the flanks, in the curtain which joins them, and in those parts of the faces of the bastions which command the ditch of the front ravelin. All these embrazures must be ready to open, and the heavy artillery mounted in them, the moment the enemy attempts to form a lodgment on the glacis. We have now arrived at the crisis of the siege, and every effort should be made to take advantage of this favourable moment, when the enemy, by his own works, must mask his former batteries, and before he is able to open his new ones.

EXERCISE OF ARTILLERY.

The several exercises are divided into three classes, as follows:—

1. Exercise of field artillery.
2. Exercise of garrison or siege artillery.
3. Exercise of the various machines employed in the manœuvres of garrison or siege artillery.

1. *Exercise of Field Artillery.*

The complement of men for the service of each gun or howitzer is, one non-commissioned officer and eight gunners.

Numbering and Telling Off the Detachments.

The several detachments being arranged right in front, are numbered and told off by their respective non-commissioned officers in the following manner: Exercises.

The non-commissioned officer is invariably No. 1, and is responsible for the proper execution of the duties of the other numbers of his detachment. The right-hand man of the rear rank is named No. 2; his front-rank man No. 3; the second man from the right of the rear rank No. 4; and his front-rank man No. 5; and so on in succession from the right of the rear to the left of the front rank, till the numbering of the whole detachment is completed.

Formation in Order of March, or for Exercise.

When detachments are formed in the order of march, or for the purpose of exercise, the even numbers are almost invariably on the right or off-side of the gun, and the odd numbers on the left or near side.

Positions of the several Numbers in Action.

No. 1 is on the left of the handspike; No. 2 outside the right wheel, in line with the muzzle; No. 3 outside the left wheel, and also in line with the muzzle; No. 4 clear of the right wheel, covering No. 2, and in line with the breech; No. 5 clear of the left wheel, covering No. 3, and also in line with the breech; No. 6 five paces in rear of and covering the left wheel; No. 7 in rear of the limber; No. 8 ten yards in rear of the gun, in line with the heads of the leading horses of the limber; and No. 9 attends the ammunition-waggon.

Duties of the several Numbers.

No. 1 points and commands; No. 2 sponges; No. 3 loads; No. 4 serves the vent and primes; No. 5 fires; No. 6 serves No. 3 with ammunition; No. 7 supplies No. 6 with ammunition, and, when firing shells, fixes the fuses; No. 8 assists No. 7, and occasionally relieves No. 2, or, when attached to $5\frac{1}{2}$ inch or 24-pounder howitzers, provides No. 3 with shells; No. 9 assists in preparing ammunition.

Limbering up, or Retiring from Action.

This manœuvre may be performed, according to circumstances, to the front, rear, right, or left. In limbering up to the front, the limber drives up to the right of the gun. No. 2 instantly passes his sponge over the axletree to No. 4, who straps on the sponge head; No. 2 and No. 3 go round to the trail; No. 4 and No. 5 man the wheels, assisted by No. 7 and No. 8 with heavy guns. The right wheel is run back, the left forward, and No. 1 and No. 6 throw the trail round in the opposite direction to that in which the limber drives up. The instant the trail is round, No. 1 unships his handspike, and No. 5 straps it on; No. 2 buckles on the rammer-head of his sponge, and the whole fall in close to the wheels. No. 6, No. 4, and No. 2 on one side, No. 5, No. 3, and No. 1 on the other; No. 7 attends the limber, and No. 8 moves up to his place. On the limber coming up square to the front, No. 1 orders, "halt, limber up," upon which No. 4 and No. 5 man the wheels, No. 2, No. 3, and No. 6, lift the trail and place it on the pintail; No. 1 then puts in the key, and the detachment mount, or fall into the order of march. The duties are precisely the same in limbering up to the rear, right, or left, except that in limbering up to the right or left, the trail and limber both go to the right or left; and in limbering up to the rear, the limber drives up rather to the right of the trail, which is not thrown round, and then reverses to the left.

Unlimbering or coming into Action.

This is precisely the reverse of the preceding manœuvre. No. 1 unkeys the pintail, No. 2 and No. 3 raise the trail,

and when it is clear No. 1 gives the word, "Drive on;" upon which the limber goes off to the left about, and the trail is thrown to the right about, the other numbers assisting as they arrive, the same as in limbering up, No. 6 at the trail with heavy guns, and No. 4 and No. 5 at the wheels. As soon as the trail is down, No. 5 unbuckles the handspike, and No. 1 ships it; No. 2 unstraps the rammer-head and goes to his place; No. 4 unstraps the sponge, and passes it over to No. 2. When the limber is sufficiently to the rear, it reverses to its left, and halts ten yards in rear of and covering its gun. The ammunition-waggon also reverses to its left, goes off in front of the limber, and again reversing to its left, halts one horse's length in rear of the gun-limber. No. 1 is responsible for the correct dressing of his gun when it comes into action; and for this purpose, immediately after the trail is in its proper direction he should place himself in line with the axle-tree of the gun upon which the formation is made, and dress his own gun with it. This position will enable him to see, not only that his gun is in its true *alignement*, but also that it is square to the front.

2. *Exercise of Garrison or Siege Artillery.*

This second branch of the exercises relates to the manner of working and serving guns, howitzers, carronades, and mortars, on batteries. The complement of men for the service of garrison or battery guns is, for the 42-pounder and 32-pounder, one non-commissioned officer and six gunners each; for the 24-pounder, one non-commissioned officer and five gunners; for the 18-pounder, one non-commissioned officer and four gunners; and for the 12-pounder and 9-pounder, one non-commissioned officer and three gunners each. The complement of men, duties, &c. are precisely the same for howitzers and carronades as the above for guns. The 13-inch mortar requires one non-commissioned officer and five gunners; the 10-inch mortar one non-commissioned officer and four gunners; the 8-inch mortar one non-commissioned officer and three gunners; and the royal and cœhorn mortars one non-commissioned officer and two gunners each.

All calculations for the daily service of guns on batteries, whether in garrison or at a siege, should be made in three proportions and at three reliefs.

Numbering, Telling Off the Detachments, and Formation for Exercise.

The same in every respect as for field artillery.

Positions and Duties of the Numbers.

No. 1, directly in rear of the gun, points, commands, and assists to run the gun up; No. 2, on the right of and in line with the muzzle, sponges, runs up, and elevates; No. 3, on the left of the muzzle, and also in line with it, loads, runs up, and elevates; No. 4, on the right of the gun, clear of the track, and in line with the breech, serves the vent, primes, runs up, and traverses; No. 5, in the same relative position on the left of the gun, fires, runs up, and traverses; the remaining numbers on the right and left of the embrazure, with their backs to the merlons. No. 6 serves No. 3 with ammunition, and runs up; No. 7 assists to run up. The whole of the numbers, when not immediately employed in working the gun, should range themselves in order under cover of the parapet.

In serving mortars, No. 1 is directly in rear of the mortar, and points, commands, and serves the vent; No. 2, on the right of and in line with the front of the bed, sponges, runs up, and traverses; No. 3, in the same relative position on the left of the bed, loads, runs up, and traverses; No. 4, on the right of the mortar, covering No. 2, and in line with the vent, runs up, elevates, supplies shells, primes, and traverses; No. 5, in the same relative position on the left of the mortar, runs up, supplies shells, elevates, traverses, and fires; No. 6, at the magazine, serves ammunition. No. 2 puts the shells into the 8-inch royal and cœhorn mortars, and in putting them into the 13 and 10-inch mortars is assisted by No. 3.

3. *Exercise of the various Machines employed in the Manœuvres of Heavy Artillery.*

The method of numbering, telling off, &c. is the same in every respect for this branch of the exercises as for the two preceding, except that, in the exercise of the devil-carriage, the odd numbers are posted on the right side, and the even numbers on the left.

Exercise of the Triangle Gyn.

The complement of men for a triangle gyn is usually one non-commissioned officer and ten gunners. The following are the duties in working or carrying the gyn:

Left side.	*Right Side.*
No. 3 carries at the foot of the left cheek, works the left-hand lever, keys and unkeys the left-hand capsquare of the gun-carriage, and assists to run the carriage up or back.	No. 2 carries at the foot of the right cheek, works the right-hand lever, keys and unkeys the right-hand capsquare of the gun-carriage, and assists to run the carriage up or back.
No. 5 carries at the top of the left cheek, works the left centre lever, and assists to run the carriage up or back.	No. 4 carries at the top of the right cheek, works the right centre lever, and assists to run the carriage up or back.
No. 7 carries the levers and handspikes, assists No. 6 in passing the fall round the windlass, and holds on next to him.	No. 6 carries the windlass, passes the fall round it, holds on, makes it fast, and eases off and lowers the gun.
No. 9 carries at the top of the pry-pole with the slings, fid, trucks, &c., holds on the fall behind No. 8, and coils it up as it comes off.	No. 8 carries at the foot of the pry-pole with the slings, fid, trucks, &c., and holds on next to No. 7.
No. 11 Assists in carrying the blocks and fall, reeves and unreeves the triple block, assists in slinging the gun, and steadies it at the muzzle.	No. 10 assists in carrying the blocks and fall, reeves and unreeves the double block, assists in slinging the gun, and steadies it at the cascable.

Exercise of Bell's Gyn.

The complement of men for working this gyn is one non-commissioned officer and six gunners.

Left side.	*Right side.*
No. 3 runs the carriage up or back, assists No. 6 in slinging the gun, turns the winch, assisted by No. 5, or makes fast and hauls upon the rope which is passed round the handles of the winch.	No. 2 runs the carriage up or back, assists No. 7 in slinging the gun, turns the winch, assisted by No. 4, or holds on upon the rope and makes it fast, the same as No. 3.
No. 5 runs the carriage up or back, and assists No. 3 at the winch.	No. 4 performs similar duties to No. 5 on his own side.
No. 7 slings and unslings the gun at the chace, assisted by No. 3, and steadies at the muzzle.	No. 6 slings and unslings the gun at the first reinforce, assisted by No. 3, places the bed and quoin, and steadies the gun at the cascable.

Exercise of the Sling-cart.

The complement of men for a sling-cart is one non-commissioned officer and six gunners.

Left side.

No. 3 has charge of the left lever, and when necessary assists to sling the gun.

No. 5 assists No. 3 at the lever and skidding, and when the gun is lashed assists in raising the breech.

No. 7 assists No. 3 at the lever, slings and unslings the gun, and lashes it to the pry-pole.

Right side.

No. 2 has charge of the right lever, and when necessary assists to skid the gun.

No. 4 in like manner assists No. 2, and when the gun is lashed assists in raising the breech.

No. 6 assists No. 2 at the lever, in slinging and unslinging the gun, and lashing it to the pry-pole.

The non-commissioned officer puts in and takes out the pauls, and commands.

Exercise of the Devil-carriage.

The complement of men for working this carriage is one non-commissioned officer and ten gunners.

Left side.

No. 2 has charge of a drag-rope, assists in hauling the perch up and down, assists No. 3 in bearing the muzzle down, and, when the gun and carriage are lashed on, puts up the skid.

Right side.

No. 3 has charge of a drag-rope, assists in hauling the perch up and down, bears the muzzle of the gun down, and, when the breech is raised, puts the lever into the muzzle.

No. 4 steadies the gun-carriage when raised on its breast transom, and with the long guy-rope lashes its front axle-tree to the devil-carriage.

No. 5. The duties of No. 5 are in all respects the same as those of No. 4.

No. 6 slings the gun, lashes the breech to the perch, assists in limbering up and unlimbering, and slings the gun-carriage.

No. 7. The duties of No. 7 are the same as those of No. 6, only performed on his own side of the carriage.

No. 8 has charge of one of the short guys, assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch; lashes the hind axle-tree of the gun-carriage to the devil-carriage, and fixes the long guy-rope to the iron eyes at the end of the perch.

No. 9 does the same as No. 8.

No. 10 assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch; lashes with the short guy-ropes the rear axle-tree of the gun-carriage to the devil-carriage, and fixes the short guy-ropes to the ring under the perch.

No. 11 does the same as No. 10.

(F. F.)

Artillery Park, the place in the rear of both lines of an army for encamping the artillery, which is drawn up in lines, of which one is formed by the guns; the ammunition-waggons make two or three lines, 60 paces behind the guns, and 30 distant from one another; the pontoons and tumbrils make the last line. The whole is surrounded by a rope, which forms the park; the gunners and matrosses encamp on the flanks; and the bombardiers, pontoon-men, and artificers, in the rear.

Artillery Train, a certain number of pieces of ordnance mounted on carriages, with all their furniture fit for marching.

Artillery Company, a band of infantry, consisting of 600 men, making part of the militia or city guard of London.

ARTIST, in a general sense, a person skilled in some art. Mr Harris defines an artist to be "a person possessing an habitual power of becoming the cause of some effect, according to a system of various and well-approved precepts." It is generally applied to an individual who practises the liberal arts as a profession.

ARTLENBURG, a bailiwick in the province of Luneburg, in the kingdom of Hanover, extending over 27 square miles, or 17,280 acres, and containing 3020 inhabitants. A town of the same name, with 525 inhabitants, is the capital of the bailiwick. It is on the banks of the Elbe, and enjoys the benefit of a toll over the river.

ARTOTYRITES, a Christian sect in the primitive church, who celebrated the eucharist with bread and cheese, saying that the first oblations of men were not only of the fruits of the earth, but of their flocks. The word is derived from αρτος, *bread*, and τυρος, *cheese*. The Artotyrites admitted women to the priesthood and episcopacy; and Epiphanius tells us it was a common thing to see seven girls at once enter into their church, robed in white and holding a torch in their hand, where they wept and bewailed the wretchedness of human nature and the miseries of this life.

ARTS.

Art is defined by Lord Bacon as a proper disposal of the things of nature by human thought and experience, so as to answer the several purposes of mankind; in which sense *art* stands opposed to *nature*.

Art is principally used for a system of rules serving to facilitate the performance of certain actions; in which sense it stands opposed to *science*, or a system of speculative principles.

Arts are commonly divided into useful or mechanic, fine or liberal. The former are those wherein the hand and body are more concerned than the mind; of which kind are most of those which furnish us with the necessaries of life, and are popularly known by the name of trades. The latter are such as depend more on the labour of the mind than of the hand; they are the produce of imagination and taste, and their end is pleasure.

USEFUL ARTS.

Some useful arts must be nearly coeval with the human race; for food, clothing, and habitation, even in their original simplicity, require some art. Many other arts are of such antiquity as to place the inventors beyond the

reach of tradition. Several have gradually crept into the world without an inventor. The busy mind, however, accustomed to a beginning in things, cannot rest till it finds or imagines a beginning to every art. The most probable conjectures of this nature the reader may see in the historical introductions to the different articles. Lord Kames, in his *Sketches of the History of Man*, has given some curious illustrations of the progress of the arts.

In all countries where the people are barbarous and illiterate, the progress of arts is extremely slow. It is vouched by an old French poem, that the virtues of the loadstone were known in France before the year 1180. The mariner's compass was exhibited at Venice anno 1260, by Paulus Venetus, as his own invention. John Goya of Amalfi was the first who, many years afterwards, used it in navigation, and also passed for being the inventor. Though it was used in China for navigation long before it was known in Europe, yet to this day it is not so perfect as in Europe. Instead of suspending it in order to make it act freely, it is placed upon a bed of sand, in which position every motion of the ship disturbs its operation. Handmills, termed *querns*, were early used for grinding corn; and when corn came to be raised in greater quantity, horse-mills succeeded. Water-mills for grinding corn are described by Vitruvius. Wind-mills were known in Greece and in Arabia as early as the 7th century, and yet no mention is made of them in Italy till the 14th. That they were not known in England till the reign of Henry VIII. appears from a household book of an earl of Northumberland, contemporary with that king, stating an allowance for three mill-horses, "two to draw in the mill, and one to carry stuff to and from the mill." Water-mills for corn must in England have been of a later date. The ancients had mirror-glasses, and employed glass to imitate crystal vases and goblets; yet they never thought of using it in windows. In the 13th century the Venetians were the only people who had the art of making crystal glass for mirrors. A clock that strikes the hours was unknown in Europe till the end of the 12th century; and hence the custom of employing men to proclaim the hours during night. Galileo was the first who conceived an idea that a pendulum might be used for measuring time; and Huygens was the first who put the idea in execution, by making a pendulum clock. Hooke, in the year 1660, invented a spiral spring for a watch, though a watch was far from being a new invention. Paper was made no earlier than the 14th century; and the invention of printing was a century later. Silk manufactures were long established in Greece before silk-worms were introduced there. The manufacturers were provided with raw silk from Persia; but that commerce being frequently interrupted by war, two monks, in the reign of Justinian, brought eggs of the silk-worm from Hindostan, and taught their countrymen the method of managing them. The art of reading made a very slow progress: to encourage that art in England, the capital punishment for murder was remitted if the criminal could but read, which in law language is termed *benefit of clergy*. One would imagine that the arts must have made a very rapid progress when so greatly favoured: but there is a signal proof of the contrary; for so small an edition of the Bible as 600 copies, translated into English in the reign of Henry VIII., was not wholly sold off in three years.

The discoveries of the Portuguese on the west coast of Africa is a remarkable instance of the slow progress of arts. In the beginning of the 15th century they were totally ignorant of that coast beyond Cape Non, 28 degrees north latitude. In 1410 the celebrated Prince Henry of Portugal fitted out a fleet for discoveries, which proceeded along the coast to Cape Bajadore, in 28 degrees, but had not courage to double it. In 1418 Tristan Vaz discovered the island Porto Santo; and the year after the island Madeira was discovered. In 1439 a Portuguese captain doubled Cape Bajadore; and the next year the Portuguese reached Cape Blanco, lat. 20 degrees. In 1446 Nuna Tristan doubled Cape de Verde, lat. 14. 40. In 1448 Don Gonzallo Vallo took possession of the Azores. In 1449 the islands of Cape de Verde were discovered for Don Henry. In 1471 Pedro d'Escovar discovered the island St Thomas and Prince's Island. In 1484 Diego Cam discovered the kingdom of Congo. In 1486 Bartholomew Diaz, employed by John II. of Portugal, doubled the Cape of Good Hope, which he called *Cabo Tormentoso*, from the tempestuous weather he found in the passage.

The progress of art seldom fails to be rapid when a people happen to be roused out of a torpid state by some fortunate change of circumstances. Prosperity, contrasted with former abasement, gives to the mind a spring, which is vigorously exerted in every new pursuit. The Athenians made but a mean figure under the tyranny of Pisistratus, but upon regaining freedom and independence they were converted into heroes. Miletus, a Greek city of Ionia, being destroyed by the king of Persia, and the inhabitants made slaves, the Athenians, deeply affected with the misery of their brethren, boldly attacked the king in his own dominions, and burnt the city of Sardis. In less than ten years after, they gained a signal victory at Marathon; and, under Themistocles, made head against that prodigious army with which Xerxes threatened utter ruin to Greece. Such prosperity produced its usual effects: arts flourished with arms, and Athens became the chief theatre for sciences, as well as for fine arts. The reign of Augustus Cæsar, which put an end to the rancour of civil war, and restored peace to Rome, with the comforts of society, proved an auspicious era for literature, and produced a cloud of Latin historians, poets, and philosophers, to whom the moderns are indebted for their taste and talents. One who makes a figure rouses emulation in all: one catches fire from another, and the national spirit is everywhere triumphant; classical works are composed, and useful discoveries made in every art and science. With regard to Rome, it is true that the Roman government under Augustus was in effect despotic; but despotism in that single instance made no obstruction to literature, it having been the policy of that reign to hide power as much as possible. A similar revolution happened in Tuscany about three centuries ago. That country having been divided into a number of small republics, the people, excited by mutual hatred between small nations in close neighbourhood, became ferocious and bloody, flaming with revenge for the slightest offence. These republics being united under the great duke of Tuscany, enjoyed the sweets of peace in a mild government. That comfortable revolution, which made the deeper impression by a retrospect of recent calamities, roused the national spirit, and produced ardent application to arts and literature. The restoration of the royal family in England, which put an end to a cruel and envenomed civil war, promoted improvements of every kind; arts and industry made a rapid progress among the people, though left to themselves by a weak and fluctuating administration. Had the nation, upon that favourable turn of fortune, been blessed with a succession of able and virtuous princes, to what a height might not arts and sciences have been carried!

Another cause of activity and animation is the being engaged in some important action of doubtful issue,—a struggle for liberty, the resisting a potent invader, or the like. Greece, divided into small states frequently at war with each other, advanced literature and the fine arts to

unrivalled perfection. The Corsicans, while engaged in a perilous war for defence of their liberties, exerted a vigorous national spirit; they founded a university for arts and sciences, a public library, and a public bank. After a long stupor during the dark ages of Christianity, arts and literature revived among the turbulent states of Italy. The Royal Society in London, and the Academy of Sciences in Paris, were both of them instituted after civil wars that had animated the people and roused their activity.

In a country thinly peopled, where even necessary arts want hands, it is common to see one person exercising more arts than one. In every populous country, even simple arts are split into parts, and each part has an artist appropriated to it. In the large towns of ancient Egypt a physician was confined to a single disease. In mechanic arts that method is excellent. As a hand confined to a single operation becomes both expert and expeditious, a mechanic art is perfected by having its different operations distributed among the greatest number of hands: many hands are employed in making a watch, and a still greater number in manufacturing a web of woollen cloth. Various arts or operations carried on by the same man invigorate his mind, because they exercise different faculties; and as he cannot be equally expert in every art or operation, he is frequently reduced to supply want of skill by thought and invention. Constant application, on the contrary, to a single operation, confines the mind to a single object, and excludes all thought and invention. In such a train of life the operator becomes dull and stupid, like a beast of burden. The difference is visible in the manners of the people. In a country where, from want of hands, several occupations must be carried on by the same person, the people are knowing and conversable: in a populous country, where manufactures flourish, they are ignorant and unsociable. The same effect is equally visible in countries where an art or manufacture is confined to a certain class of men. It is visible in Hindostan, where the people are divided into castes, which never mix even by marriage, and where every man follows his father's trade. The Dutch lint-boors are a similar instance: the same family carries on the trade from generation to generation, and are accordingly ignorant and brutish even beyond other Dutch peasants.

Useful arts pave the way to fine arts. Men upon whom the former had bestowed every convenience, turned their thoughts to the latter. Beauty was studied in objects of sight; and men of taste attached themselves to the fine arts, which multiplied their enjoyments and improved their benevolence. Sculpture and painting made an early figure in Greece, which afforded plenty of beautiful originals to be copied in these imitative arts. Statuary, a more simple imitation than painting, was sooner brought to perfection. The statue of Jupiter by Phidias, and of Juno by Polycletes, though the admiration of all the world, were executed long before the art of light and shade was known. Apollodorus, and Zeuxis his disciple, who flourished in the 95th olympiad, were the first who figured in that art. Another cause concurred to advance statuary before painting in Greece, viz. a great demand for statues of their gods. Architecture, as a fine art, made a slower progress. Proportions, upon which its elegance chiefly depends, cannot be accurately ascertained, but by an infinity of trials in great buildings. A model cannot be relied on; for a large and a small building, even of the same form, require different proportions.

FINE ARTS.

The term Fine Arts may be viewed as embracing all those arts in which the powers of imitation or invention are exerted, chiefly with a view to the production of pleasure by the immediate impression which they make on the mind. But the phrase has of late, we think, been restricted to a narrower and more technical signification; namely, to painting, sculpture, engraving, and architecture, which appeal to the eye as the medium of pleasure; and, by way of eminence, to the two first of these arts. In the following observations we shall adopt this limited sense of the term; and shall endeavour to develope the principles upon which the great masters have proceeded, and also to inquire, in a more particular manner, into the state and probable advancement of these arts in this country.

The great works of art at present extant, and which may be regarded as models of perfection in their several kinds, are the Greek statues—the pictures of the celebrated Italian masters—those of the Dutch and Flemish schools—to which we may add the comic productions of our own countryman Hogarth. These all stand unrivalled in the history of art; and they owe their pre-eminence and perfection to one and the same principle,—*the immediate imitation of nature.* This principle predominated equally in the classical forms of the antique and in the grotesque figures of Hogarth: the perfection of art in each arose from the truth and identity of the imitation with the reality; the difference was in the subjects—there was none in the mode of imitation. Yet the advocates for the *ideal system of art* would persuade their disciples, that the difference between Hogarth and the antique does not consist in the different forms of nature which they imitated, but in this, that the one is like and the other unlike nature. This is an error the most detrimental perhaps of all others, both to the theory and practice of art. As, however, the prejudice is very strong and general, and supported by the highest authority, it will be necessary to go somewhat elaborately into the question in order to produce an impression on the other side.

What has given rise to the common notion of the *ideal*, as something quite distinct from *actual* nature, is probably the perfection of the Greek statues. Not seeing among ourselves any thing to correspond in beauty and grandeur, either with the features or form of the limbs in these exquisite remains of antiquity, it was an obvious, but a superficial conclusion, that they must have been created from the idea existing in the artist's mind, and could not have been copied from any thing existing in nature. The contrary, however, is the fact. The general form, both of the face and figure, which we observe in the old statues, is not an ideal abstraction, is not a fanciful invention of the sculptor, but is as completely local and national (though it happens to be more beautiful) as the figures on a Chinese screen, or a copperplate engraving of a negro chieftain in a book of travels. It will not be denied that there is a difference of physiognomy as well as of complexion in different races of men. The Greek form appears to have been naturally beautiful, and they had, besides, every advantage of climate, of dress, of exercise, and modes of life to improve it. The artist had also every facility afforded him in the study and knowledge of the human form; and their religious and public institutions gave him every encouragement in the prosecution of this art. All these causes contributed to the perfection of these noble productions; but we should be inclined principally to attribute the superior symmetry of form common to the Greek statues, in the first place, to the superior symmetry of the models in nature; and in the second, to the more constant opportunities for studying them. If we allow, also, for the superior genius of the people, we shall not be wrong; but this superiority consisted in their peculiar susceptibility to the impres-

sions of what is beautiful and grand in nature. It may be thought an objection to what has just been said, that the antique figures of animals, &c., are as fine, and proceed on the same principles, as their statues of gods or men. But all that follows from this seems to be, that their art had been perfected in the study of the human form, the test and proof of power and skill; and was then transferred easily to the general imitation of all other objects, according to their true characters, proportions, and appearances. As a confirmation of these remarks, the antique portraits of individuals were often superior even to the personifications of their gods. We think that no unprejudiced spectator of real taste can hesitate for a moment in preferring the head of the Antinous, for example, to that of the Apollo. And in general it may be laid down as a rule, that the most perfect of the antiques are the most simple,—those which affect the least action, or violence of passion,—which repose the most on natural beauty of form, and a certain expression of sweetness and dignity, that is, which remain most nearly in that state in which they could be copied from nature without straining the limbs or features of the individual, or racking the invention of the artist. This tendency of Greek art to repose has indeed been reproached with insipidity by those who had not a true feeling of beauty and sentiment. We, however, prefer these models of habitual grace or internal grandeur to the violent distortions of suffering in the Laocoon, or even to the supercilious air of the Apollo. The Niobe, more than any other antique head, combines truth and beauty with deep passion. But here the passion is fixed, intense, habitual;—it is not a sudden or violent gesticulation, but a settled mould of features; the grief it expresses is such as might almost turn the human countenance itself *into marble!*

In general, then, we would be understood to maintain, that the beauty and grandeur so much admired in the Greek statues were not a voluntary fiction of the brain of the artist, but existed substantially in the forms from which they were copied, and by which the artist was surrounded. A striking authority in support of these observations, which has in some measure been lately discovered, is to be found in the *Elgin marbles*, taken from the Acropolis at Athens, and supposed to be the works of the celebrated Phidias. The process of fastidious refinement and indefinite abstraction is certainly not visible there. The figures have all the ease, the simplicity, and variety, of individual nature. Even the details of the subordinate parts, the loose hanging folds in the skin, the veins under the belly or on the sides of the horses, more or less swelled as the animal is more or less in action, are given with scrupulous exactness. This is true nature and true art. In a word, these invaluable remains of antiquity are precisely like casts taken from life. The *ideal* is not the preference of that which exists only in the mind to that which exists in nature; but the preference of that which is fine in nature to that which is less so. There is nothing fine in art but what is taken almost immediately, and, as it were, in the mass, from what is finer in nature. Where there have been the finest models in nature, there have been the finest works of art.

As the Greek statues were copied from Greek forms, so Raphael's expressions were taken from Italian faces; and we have heard it remarked, that the women in the streets at Rome seem to have walked out of his pictures in the Vatican.

Sir Joshua Reynolds constantly refers to Raphael as the highest example in modern times (at least with one exception) of the grand or ideal style; and yet he makes the essence of that style to consist in the embodying of an abstract or general idea, formed in the mind of the artist by rejecting the peculiarities of individuals, and retaining only what is common to the species. Nothing can be more inconsistent than the style of Raphael with this definition. In his Cartoons, and in his groupes in the Vatican, there is hardly a face or figure which is any thing more than fine individual nature finely disposed and copied. The late Mr Barry, who could not be suspected of prejudice on this side of the question, speaks thus of them: "In Raphael's pictures (at the Vatican) of the *Dispute of the Sacrament*, and the *School of Athens*, one sees all the heads to be entirely copied from particular characters in nature, nearly proper for the persons and situations which he adapts them to; and he seems to me only to add and take away what may answer his purpose in little parts, features, &c.; conceiving, while he had the head before him, ideal characters and expressions, which he adapts these features and peculiarities of face to. This attention to the particulars which distinguish all the different faces, persons, and characters, the one from the other, gives his pictures quite the verity and unaffected dignity of nature, which stamp the distinguishing differences betwixt one man's face and body and another's."

If any thing is wanting to the conclusiveness of this testimony, it is only to look at the pictures themselves; particularly the *Miracle of the Conversion*, and the *Assembly of Saints*, which are little else than a collection of divine portraits, in natural and expressive attitudes, full of the loftiest thought and feeling, and as varied as they are fine. It is this reliance on the power of nature which has produced those masterpieces by the prince of painters, in which expression is all in all;—where one spirit—that of truth—pervades every part, brings down heaven to earth, mingles cardinals and popes with angels and apostles,—and yet blends and harmonizes the whole by the true touches and intense feeling of what is beautiful and grand in nature. It is no wonder that Sir Joshua, when he first saw Raphael's pictures in the Vatican, was at a loss to discover any great excellence in them, if he was looking out for his theory of the *ideal*,—of neutral character and middle forms.

There is more an appearance of abstract grandeur of form in Michael Angelo. He has followed up, has enforced, and expanded, as it were, a preconceived idea, till he sometimes seems to tread on the verge of caricature. His forms, however, are not *middle*, but *extreme* forms, massy, gigantic, supernatural. They convey the idea of the greatest size and strength in the figure, and in all the parts of the figure. Every muscle is swollen and turgid. This tendency to exaggeration would have been avoided if Michael Angelo had recurred more constantly to nature, and had proceeded less on a scientific knowledge of the structure of the human body; for science gives only the positive form of the different parts, which the imagination may afterwards magnify as it pleases; but it is nature alone which combines them with perfect truth and delicacy, in all the varieties of motion and expression. It is fortunate that we can refer, in illustration of our doctrine, to the admirable fragment of the Theseus at Lord Elgin's, which shows the possibility of uniting the grand and natural style in the highest degree. The form of the limbs, as affected by pressure or action, and the general sway of the body, are preserved with the most consummate mastery. We should prefer this statue as a model for forming the style of the student to the Apollo, which strikes us as having something of a theatrical appearance; or to the Hercules, in which there is an ostentatious and over-laboured display of anatomy. This last figure is so overloaded with sinews, that it has been suggested as a doubt, whether, if life could be put into it, it would be able to move. Grandeur of conception, truth of nature, and pu-

rity of taste, seem to have been at their height when the masterpieces which adorned the Temple of Minerva at Athens, of which we have only these imperfect fragments, were produced. Compared with these, the later Greek statues display a more elaborate workmanship, more of the artifices of style. The several parts are more uniformly balanced, made more to tally like modern periods; each muscle is more equally brought out, and more highly finished as a part, but not with the same subordination of each part to the whole. If some of these wonderful productions have a fault, it is the want of that entire and naked simplicity which pervades the whole of the *Elgin marbles*.

Work of the Grecian and Italian artists.

Having spoken here of the Greek statues, and of the works of Raphael and Michael Angelo, as far as relates to the imitation of nature, we shall attempt to point out, to the best of our ability, and as concisely as possible, what we conceive to be their general and characteristic excellences. The ancients excelled in beauty of form; Michael Angelo in grandeur of conception; Raphael in expression. In Raphael's faces, particularly his women, the expression is very superior to the form; in the ancient statues the form is the principal thing. The interest which the latter excite is in a manner external; it depends on a certain grace and lightness of appearance, joined with exquisite symmetry and refined susceptibility to voluptuous emotions; but there is in general a want of pathos. In their looks we do not read the workings of the heart; by their beauty they seem raised above the sufferings of humanity; by their beauty they are deified. The pathos which they exhibit is rather that of present and physical distress, than of deep internal sentiment. What has been remarked of Leonardo da Vinci, is also true of Raphael, that there is an angelic sweetness and tenderness in his faces, in which human frailty and passion are purified by the sanctity of religion. The ancient statues are finer objects for the eye to contemplate; they represent a more perfect race of physical beings, but we have little sympathy with them. In Raphael, all our natural sensibilities are heightened and refined by the sentiments of faith and hope, pointing mysteriously to the interests of another world. The same intensity of passion appears also to distinguish Raphael from Michael Angelo. Michael Angelo's forms are grander, but they are not so informed with expression. Raphael's, however ordinary in themselves, are full of expression, "even to o'erflowing;" every nerve and muscle is impregnated with feeling,—bursting with meaning. In Michael Angelo, on the contrary, the powers of body and mind appear superior to any events that can happen to them; the capacity of thought and feeling is never full, never strained or tasked to the extremity of what it will bear. All is in a lofty repose and solitary grandeur, which no human interest can shake or disturb. It has been said that Michael Angelo painted *man*, and Raphael *men*; that the one was an epic, the other a dramatic painter. But the distinction we have stated is, perhaps, truer and more intelligible, viz. that the one gave greater dignity of form, and the other greater force and refinement of expression. Michael Angelo, in fact, borrowed his style from sculpture. He represented, in general, only single figures (with subordinate accompaniments), and had not to express the conflicting actions and passions of a multitude of persons. It is therefore a mere truism to say that his compositions are not dramatic. He is much more picturesque than Raphael. The whole figure of his *Jeremiah* droops and hangs down like a majestic tree surcharged with showers. His drawing of the human form has the characteristic freedom and boldness of Titian's landscapes.

After Michael Angelo and Raphael, there is no doubt that Leonardo da Vinci and Correggio are the two painters, in modern times, who have carried historical expression to the highest ideal perfection; and yet it is equally certain that their heads are carefully copied from faces and expressions in nature. Leonardo excelled principally in his women and children. We find, in his female heads, a peculiar charm of expression; a character of natural sweetness and tender playfulness, mixed up with the pride of conscious intellect and the graceful reserve of personal dignity. He blends purity with voluptuousness; and the expression of his women is equally characteristic of "the mistress or the saint." His pictures are worked up to the height of the idea he had conceived, with an elaborate felicity; but this idea was evidently first suggested, and afterwards religiously compared with nature. This was his excellence. His fault is, that his style of execution is too mathematical; that is, his pencil does not follow the graceful variety of the details of objects, but substitutes certain refined gradations, both of form and colour, producing equal changes in equal distances, with a mechanical uniformity. Leonardo was a man of profound learning as well as genius, and perhaps transferred too much of the formality of science to his favourite art.

The masterpieces of Correggio have the same identity with nature, the same stamp of truth. He has indeed given to his pictures the utmost softness and refinement of outline and expression; but this idea, at which he constantly aimed, is filled up with all the details and varieties which such heads would have in nature. So far from any thing like a naked abstract idea, or middle form, the *individuality* of his faces has something peculiar in it, even approaching the grotesque. He has endeavoured to impress habitually on the countenance those undulating outlines which rapture or tenderness leave there, and has chosen for this purpose those forms and proportions which most obviously assisted his design.

As to the colouring of Correggio, it is nature itself. Not only is the general tone perfectly true, but every speck and particle is varied in colour, in relief, in texture, with a care, a felicity, and an effect, which is almost magical. His light and shade are equally admirable. No one else, perhaps, ever gave the same harmony and roundness to his compositions. So true are his shadows,—equally free from coldness, opacity, or false glare;—so clear, so broken, so airy, and yet so deep, that if you hold your hand so as to cast a shadow on any part of the flesh which is in the light, this part, so shaded, will present exactly the same appearance which the painter has given to the shadowed part of the picture. Correggio, indeed, possessed a greater variety of excellences in the different departments of his art than any other painter; and yet it is remarkable, that the impression which his pictures leave upon the mind of the common spectator is monotonous and comparatively feeble. His style is in some degree mannered and confined. For instance, he is without the force, passion, and grandeur of Raphael, who, however, possessed his softness of expression, but of expression only; and in colour, in light and shade, and other qualities, was quite inferior to Correggio. We may, perhaps, solve this apparent contradiction by saying, that he applied the power of his mind to a greater variety of objects than others; but that this power was still of the same character; consisting in a certain exquisite sense of the harmonious, the soft and graceful in form, colour, and sentiment, but with a deficiency of strength, and a tendency to effeminacy in all these.

After the names of Raphael and Correggio, we shall mention that of Guido, whose female faces are exceedingly beautiful and ideal, but altogether commonplace and vapid compared with those of Raphael or Correggio; and

they are so for no other reason but that the general idea they convey is not enriched and strengthened by an intense contemplation of nature. For the same reason, we can conceive nothing more unlike the antique than the figures of Nicholas Poussin, except as to the preservation of the costume; and it is perhaps chiefly owing to the habit of studying his art at second-hand, or by means of scientific rules, that the great merits of that able painter, whose understanding and genius are unquestionable, are confined to his choice of subjects for his pictures, and his manner of telling the story. His landscapes, which he probably took from nature, are superior as paintings to his historical pieces. The faces of Poussin want natural expression, as his figures want grace; but the back-grounds of his historical compositions can scarcely be surpassed. In his *Plague of Athens*, the very buildings seem stiff with horror. His giants, seated on the top of their fabled mountains, and playing on their Pan pipes, are as familiar and natural as if they were the ordinary inhabitants of the scene. The finest of his landscapes is his picture of the *Deluge*. The sun is just seen, wan and drooping in his course. The sky is bowed down with a weight of waters, and heaven and earth seem mingling together.

Titian is at the head of the Venetian school. He is the first of all colourists. In delicacy and purity Correggio is equal to him, but his colouring has not the same warmth and gusto in it. Titian's flesh-colour partakes of the glowing nature of the climate, and of the luxuriousness of the manners of his country. He represents objects not through a merely lucid medium, but as if tinged with a golden light. Yet it is wonderful in how low a tone of local colouring his pictures are painted,—how rigidly his means are husbanded. His most gorgeous effects are produced, not less by keeping down than by heightening his colours; the fineness of his gradations adds to their variety and force; and, with him, truth is the same thing as splendour. Every thing is done by the severity of his eye, by the patience of his touch. He is enabled to keep pace with nature by never hurrying on before her; and as he forms the broadest masses out of innumerable varying parts and minute strokes of the pencil, so he unites and harmonizes the strongest contrasts by the most imperceptible transitions. Every distinction is relieved and broken by some other intermediate distinction, like half-notes in music; and yet all this accumulation of endless variety is so managed as only to produce the majestic simplicity of nature, so that to a common eye there is nothing extraordinary in his pictures, any more than in nature itself. It is, we believe, owing to what has been here stated, that Titian is, of all painters, at once the easiest and the most difficult to copy. He is the most difficult to copy perfectly, for the artifice of his colouring and execution is hid in its apparent simplicity; and yet the knowledge of nature, and the arrangement of the forms and masses in his pictures, are so masterly, that any copy made from them, even the rudest outline or sketch, can hardly fail to have a look of high art. Because he was the greatest colourist in the world, this, which was his most prominent, has, for shortness, been considered as his only excellence; and he has been said to have been ignorant of drawing. What he was, generally speaking, deficient in, was invention or composition, though even this appears to have been more from habit than want of power; but his drawing of actual forms, where they were not to be put into momentary action, or adapted to a particular expression, was as fine as possible. His drawing of the forms of inanimate objects is unrivalled. His trees have a marked character and physiognomy of their own, and exhibit an appearance of strength or flexibility, solidity or lightness, as if they were endued with conscious power and purposes. Character was another excellence which Titian possessed in the highest degree. It is scarcely speaking too highly of his portraits to say, that they have as much expression, that is, convey as fine an idea of intellect and feeling, as the historical heads of Raphael. The chief difference appears to be, that the expression in Raphael is more imaginary and contemplative, and in Titian more personal and constitutional. The heads of the one seem thinking more of some event or subject, those of the other to be thinking more of themselves. In the portraits of Titian, as might be expected, the Italian character always predominates; there is a look of piercing sagacity, of commanding intellect, of acute sensibility, which it would be in vain to seek for in any other portraits. The daring spirit and irritable passions of the age and country are distinctly stamped upon their countenances, and can be as little mistaken as the costume which they wear. The portraits of Raphael, though full of profound thought and feeling, have more of common humanity about them. Titian's portraits are the most historical that ever were painted; and they are so for this reason, that they have most consistency of form and expression. His portraits of Hippolito de Medici, and of a young Neapolitan nobleman, lately in the gallery of the Louvre, are a striking contrast in this respect. All the lines of the face in the one, the eye-brows, the nose, the corners of the mouth, the contour of the face, present the same sharp angles, the same acute, edgy, contracted, violent expression. The other portrait has the finest expansion of feature and outline, and conveys the most exquisite idea possible of mild, thoughtful sentiment. The consistency of the expression constitutes as great a charm in Titian's portraits as the harmony of the colouring. The similarity sometimes objected to his heads is partly national, and partly arises from the class of persons whom he painted. He painted only Italians; and in his time it rarely happened that any but persons of the highest rank, senators or cardinals, sat for their pictures. The similarity of costume of the dress, the beard, &c. also adds to the similarity of their appearance. It adds at the same time to their picturesque effect; and the alteration in this respect is one circumstance among others that has been injurious, not to say fatal, to modern art. This observation is not confined to portrait; for the hired dresses with which our historical painters clothe their figures sit no more easily on the imagination of the artist, than they do gracefully on the lay-figures over which they are thrown.

Giorgioni, Paul Veronese, Tintoret, and the Bassans, are the remaining great names of the Venetian school. The excellence of all of them consisted in their bold, masterly, and striking imitation of nature. Their want of *ideal form* and elevated character is, indeed, a constant subject of reproach against them. Giorgioni takes the first place among them; for he was in some measure the master of Titian, whereas the others were only his disciples. The Carraccis, Domenichino, and the rest of the Bolognese school, formed themselves on a principle of combining the excellences of the Roman and Venetian painters, in which they for a while succeeded to a considerable degree; but they degenerated and dwindled away into absolute insignificance, in proportion as they departed from nature, or the great masters who had copied her, to mould their works on academic rules, and the phantoms of abstract perfection.

Flemish and Dutch painters.

Rubens is the prince of the Flemish painters. Of all the great painters, he is perhaps the most artificial,—the one who painted most from his own imagination,—and, what was almost the inevitable consequence, the most of a mannerist. He had neither the Greek forms to study

from, nor the Roman expression, nor the high character, picturesque costume, and sun-burnt hues which the Venetian painters had immediately before them. He took, however, what circumstances presented to him,—a fresher and more blooming tone of complexion, arising from moister air and a colder climate. To this he added the congenial splendour of reflected lights and shadows cast from rich drapery; and he made what amends he could for the want of expression, by the richness of his compositions, and the fantastic variety of his allegorical groups. Both his colouring and his drawing were, however, ideal exaggerations. But both had particular qualities of the highest value. He has given to his flesh greater transparency and freshness than any other painter; and this excellence he had from nature. One of the finest instances will be found in his *Peasant Family going to Market*, in which the figures have all the bloom of health upon their countenances; and the very air of the surrounding landscape strikes sharp and wholesome on the sense. Rubens had another excellence; he has given all that relates to the expression of motion in his allegorical figures, in his children, his animals, even in his trees, to a degree which no one else has equalled, or indeed approached. His drawing is often deficient in proportion, in knowledge, and in elegance, but it is always picturesque. The drawing of N. Poussin, on the contrary, which has been much cried up, is merely learned and anatomical: he has a knowledge of the structure and measurements of the human body, but very little feeling of the grand, or beautiful, or striking in form. All Rubens' forms have ease, freedom, and excessive elasticity. In the grotesque style of history,—as in the groups of satyrs, nymphs, bacchanals, and animals, where striking contrasts of form are combined with every kind of rapid and irregular movement,—he has not a rival. Witness his Silenus at Blenheim, where the lines seem drunk and staggering; and his procession of Cupids riding on animals at Whitehall, with that adventurous leader of the infantine crew, who, with a spear, is urging a lion, on which he is mounted, over the edge of the world; for beyond we only see a precipice of clouds and sky. Rubens' power of expressing motion perhaps arose from the facility of his pencil, and his habitually trusting a good deal to memory and imagination in his compositions; for this quality can be given in no other way. His portraits are the least valuable productions of his pencil. His landscapes are often delightful, and appear like the work of fairy hands.

It remains to speak of Vandyke and Rembrandt, the one the disciple of Rubens, the other the entire founder of his own school. It is not possible for two painters to be more opposite. The characteristic merits of the former are very happily summed up in a single line of a poetical critic, where he speaks of

> The soft precision of the clear Vandyke.

The general object of this analysis of the works of the great masters has been to show that their pre-eminence has constantly depended, not on the creation of a fantastic, abstract excellence, existing nowhere but in their own minds, but in their selecting and embodying some one view of nature, which came immediately under their habitual observation, and which their particular genius led them to study and imitate with success. This is certainly the case with Vandyke. His portraits, mostly of English women, in the collection in the Louvre, have a cool refreshing air about them, a look of simplicity and modesty even in the very tone, which forms a fine contrast to the voluptuous glow and mellow golden lustre of Titian's Italian women. There is a quality of flesh-colour in Vandyke which is to be found in no other painter, and which exactly conveys the idea of the soft, smooth, sliding, continuous, delicately varied surface of the skin. The objects in his pictures have the least possible difference of light and shade, and are presented to the eye without passing through any indirect medium. It is this extreme purity and silvery clearness of tone, together with the facility and precision of his particular forms, and a certain air of fashionable elegance, characteristic of the age in which he flourished, that places Vandyke in the first rank of portrait painters.

If ever there was a man of genius in the art, it was Rembrandt. He might be said to have created a medium of his own, through which he saw all objects. He was the grossest and the least vulgar, that is to say, the least common-place in his grossness, of all men. He was the most downright, the least fastidious of the imitators of nature. He took any object, he cared not what, how mean soever in form, colour, and expression; and from the light and shade which he threw upon it, it came out gorgeous from his hands. As Vandyke made use of the smallest contrasts of light and shade, and painted as if in the open air, Rembrandt used the most violent and abrupt contrasts in this respect, and painted his objects as if in a dungeon. His pictures may be said to be "bright with excessive darkness." His vision had acquired a lynx-eyed sharpness from the artificial obscurity to which he had accustomed himself. "Mystery and silence hung upon his pencil." Yet he could pass rapidly from one extreme to another, and dip his colours with equal success in the gloom of night or in the blaze of the noon-day sun. In surrounding different objects with a medium of imagination, solemn or dazzling, he was a true poet; in all the rest he was a mere painter, but a painter of no common stamp. The powers of his hand were equal to those of his eye; and indeed he could not have attempted the subjects he did, without an execution as masterly as his knowledge was profound. His colours are sometimes dropped in lumps on the canvass; at other times they are laid on as smooth as glass; and he not unfrequently painted with the handle of his brush. He had an eye for all objects as far as he had seen them. His history and landscapes are equally fine in their way. His landscapes we could look at for ever, though there is nothing in them. But "they are of the earth, earthy." It seems as if he had dug them out of nature. Every thing is so true, so real, so full of all the feelings and associations which the eye can suggest to the other senses, that we immediately take as strong an affection to them as if they were our home—the very place where we were brought up. No length of time could add to the intensity of the impression they convey. Rembrandt is the least classical and the most romantic of all painters. His *Jacob's Ladder* is more like a dream than any other picture that ever was painted. The figure of Jacob himself is thrown in one corner of the picture like a bundle of clothes, while the angels hover above the darkness in the shape of airy wings.

It would be needless to prove that the generality of the Dutch painters copied from actual objects. They have become almost a bye-word for carrying this principle into its abuse, by copying every thing they saw, and having no choice or preference of one thing to another, unless that they preferred that which was most obvious and common. We forgive them. They perhaps did better in faithfully and skilfully imitating what they had seen, than in imagining what they had not seen. Their pictures at least show that there is nothing in nature, however mean or trivial, that has not its beauty, and some interest belonging to it, if truly represented. We prefer Vangoyen's views on the borders of a canal, the yellow-

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tufted bank and passing sail, or Ruysdael's woods and sparkling water-falls, to the most classical or epic compositions which they could have invented out of nothing; and we think that Teniers' boors, old women, and children, are very superior to the little carved ivory Venuses in the pictures of Vanderneer; just as we think Hogarth's *Marriage à la Mode* is better than his *Sigismunda*, or, as Mr Wilkie's *Card-Players* is better than his *Alfred*. We should not assuredly prefer a *Dutch Fair* by Teniers to a *Cartoon* by Raphael; but we suspect we should prefer a *Dutch Fair* by Teniers to a *Cartoon* by the same master; or we should prefer truth and nature in the simplest dress, to affectation and inanity in the most pompous disguise. Whatever is genuine in art must proceed from the impulse of nature and individual genius.

French and Spanish painters.

In the French school there are but two names of high and established reputation, N. Poussin and Claude Lorraine. Of the former we have already spoken; of the latter we shall give our opinion when we come to speak of our own Wilson. We ought not to pass over the names of Murillo and Velasquez, those admirable Spanish painters. It is difficult to characterize their peculiar excellences as distinct from those of the Italian and Dutch schools. They may be said to hold a middle rank between the painters of mind and body. They express not so much thought and sentiment, nor yet the mere exterior, as the life and spirit of the man. Murillo is probably at the head of that class of painters who have treated subjects of common life. After making the colours on the canvass feel and think, the next best thing is to make them breathe and live. But there is in Murillo's pictures of this kind a look of real life, a cordial flow of native animal spirits, which we find nowhere else. We might here refer particularly to his picture of the *Two Spanish Beggar Boys*, in the collection at Dulwich College, which cannot easily be forgotten by those who have ever seen it.

Progress of art in Britain.

We come now to treat of the progress of art in Britain. We shall speak first of Hogarth, both as he is the first name in the order of time that we have to boast of, and as he is the greatest comic painter of any age or country. His pictures are not imitations of still life, or mere transcripts of incidental scenes or customs; but powerful moral satires, exposing vice and folly in their most ludicrous points of view, and, with a profound insight into the weak sides of character and manners, in all their tendencies, combinations, and contrasts. There is not a single picture of his, containing a representation of merely natural or domestic scenery. His object is not so much "to hold the mirror up to nature," as "to show vice her own feature, scorn her own image." Folly is there seen at the height—the moon is at the full—it is the very error of the time. There is a perpetual collision of eccentricities, a tilt and tournament of absurdities, pampered into all sorts of affectation, airy, extravagant, and ostentatious! Yet he is as little a caricaturist as he is a painter of still life. Criticism has not done him justice, though public opinion has. His works have received a sanction which it would be vain to dispute, in the universal delight and admiration with which they have been regarded, from their first appearance to the present moment. If the quantity of amusement, or of matter for reflection, which they have afforded, is that by which we are to judge of precedence among the intellectual benefactors of mankind, there are perhaps few persons who can put in a stronger claim to our gratitude than Hogarth. The wonderful knowledge which he possessed of human life and manners is only to be surpassed (if it can be) by the powers of invention with which he has arranged his materials, and by the mastery of execution with which he has embodied and made tangible the very thoughts and passing movements of the mind. Some persons object to the style of Hogarth's pictures, or the class to which they belong. First, Hogarth belongs to no class, or, if he belongs to any, it is to the same class as Fielding, Smollett, Vanbrugh, and Molière. Besides, the merit of his pictures does not depend on the nature of his subjects, but on the knowledge displayed of them, on the number of ideas, on the fund of observation and amusement contained in them. Make what deductions you please for the vulgarity of the subjects—yet in the research, the profundity, the absolute truth and precision of the delineation of character,—in the invention of incident, in wit and humour, in life and motion, in everlasting variety and originality,—they never have been, and probably never will be, surpassed. They stimulate the faculties, as well as amuse them. "Other pictures we see, Hogarth's we read!"[1]

There is one error which has been frequently entertained on this subject, and which we wish to correct, namely, that Hogarth's genius was confined to the imitation of the coarse humours and broad farce of the lowest life. But he excelled quite as much in exhibiting the vices, the folly, and frivolity of the fashionable manners of his time. His fine ladies do not yield the palm of ridicule to his waiting-maids, and his lords and his porters are on a very respectable footing of equality. He is quite at home, either in St Giles's or St James's. There is no want, for example, in his *Marriage à la Mode*, or his *Taste in High Life*, of affectation verging into idiotcy, or of languid sensibility that might

Die of a rose in aromatic pain.

Many of Hogarth's characters would form admirable illustrations of Pope's Satires, who was contemporary with him. In short, Hogarth was a painter of real, not of low life. He was, as we have said, a satirist, and consequently his pencil did not dwell on the grand and beautiful, but it glanced with equal success at the absurdities and peculiarities of high or low life, "of the great vulgar and the small."

To this it must be added, that he was as great a master of passion as of humour. He succeeded in low tragedy as much as in low or genteel comedy, and had an absolute power in moving the affections and rending the hearts of the spectators, by depicting the effects of the most dreadful calamities of human life on common minds and common countenances. Of this the *Rake's Progress*, particularly the bedlam scene, and many others, are unanswerable proofs. Hogarth's merits as a mere artist are not confined to his prints. In general, indeed, this is the case. But when he chose to take pains, he could add the delicacies of execution and colouring in the highest degree to those of character and composition; as is evident in his series of pictures, all equally well painted, of the *Marriage à la Mode*.

We shall next speak of Wilson, whose pictures may be divided into three classes,—his Italian landscapes, or imitations of the manner of Claude,—his copies of English scenery,—and his historical compositions. The first of these are, in our opinion, by much the best; and we appeal, in support of this opinion, to the *Apollo and the Seasons*, and to the *Phaeton*. The figures are of course out of the question (these being as uncouth and slovenly as Claude's are insipid and finical); but the landscape in both pictures is delightful. 'In looking at them we breathe the air which the scene inspires, and feel the genius of the place present to us. In the first there is the cool

[1] See an admirable essay on the genius of Hogarth, by Charles Lamb, in a periodical work called *The Reflector*.

freshness of a misty spring morning; the sky, the water, the dim horizon, all convey the same feeling. The fine grey tone and varying outline of the hills; the graceful form of the retiring lake, broken still more by the hazy shadows of the objects that repose on its bosom; the light trees that expand their branches in the air; and the dark stone figure and mouldering temple, that contrast strongly with the broad clear light of the rising day,—give a charm, a truth, a force and harmony to this composition, which produce the greater pleasure the longer it is dwelt on. The distribution of light and shade resembles the effect of light on a globe. The *Phaeton* has the dazzling fervid appearance of an autumnal evening; the golden radiance streams in solid masses from behind the flickering clouds; every object is baked in the sun;—the brown fore-ground, the thick foliage of the trees, the streams, shrunk and stealing along behind the dark high banks,—combine to produce that richness and characteristic unity of effect which is to be found only in nature, or in art derived from the study and imitation of nature. These two pictures, as they have the greatest general effect, are also more carefully finished than any other pictures we have seen of his.

In general, Wilson's views of English scenery want almost every thing that ought to recommend them. The subjects he has chosen are not well fitted for the landscape-painter, and there is nothing in the execution to redeem them. Ill-shaped mountains, or great heaps of earth,—trees that grow against them without character or elegance,—motionless waterfalls,—a want of relief, of transparency and distance, without the imposing grandeur of real magnitude (which it is scarcely within the province of art to give),—are the chief features and defects of this class of his pictures. In more confined scenes the effect must depend almost entirely on the difference in the execution and the details; for the difference of colour alone is not sufficient to give relief to objects placed at a small distance from the eye. But in Wilson there are commonly no details,—all is loose and general; and this very circumstance, which might assist him in giving the massy contrasts of light and shade, deprived his pencil of all force and precision within a limited space. In general, air is necessary to the landscape-painter; and, for this reason, the lakes of Cumberland and Westmoreland afford few subjects for landscape-painting. However stupendous the scenery of that country is, and however powerful and lasting the impression which it must always make on the imagination, yet the effect is not produced merely through the medium of the eye, but arises chiefly from collateral and associated feelings. There is the knowledge of the physical magnitude of the objects in the midst of which we are placed,—the slow, improgressive motion which we make in traversing them;—there is the abrupt precipice, the torrent's roar, the boundless expanse of the prospect from the highest mountains,—the difficulty of their ascent, their loneliness and silence;—in short, there is a constant sense and superstitious awe of the collective power of matter, of the gigantic and eternal forms of nature, on which, from the beginning of time, the hand of man has made no impression, and which, by the lofty reflections they excite in us, give a sort of intellectual sublimity even to our sense of physical weakness. But there is little in all these circumstances that can be translated into the *picturesque*, which makes its appeal immediately to the eye.

Wilson's historical landscapes, his *Niobe*, *Celadon and Amelia*, &c. do not, in our estimation, display either true taste or fine imagination, but are affected and violent exaggerations of clumsy common nature. They are made up mechanically of the same stock of materials,—an overhanging rock, bare shattered trees, black rolling clouds, and forked lightning. The figures in the most celebrated of these are not, like the children of Niobe, punished by the gods, but like a group of rustics crouching from a hail-storm. We agree with Sir Joshua Reynolds, that Wilson's mind was not, like N. Poussin's, sufficiently imbued with the knowledge of antiquity to transport the imagination three thousand years back, to give natural objects a sympathy with preternatural events, and to inform rocks, and trees, and mountains, with the presence of a God. To sum up his general character, we may observe, that, besides his excellence in aërial perspective, Wilson had great truth, harmony, and depth of local colouring. He had a fine feeling of the proportions and conduct of light and shade, and also an eye for graceful form, as far as regards the bold and varying outlines of indefinite objects, as may be seen in his foregrounds, &c., where the artist is not tied down to an imitation of characteristic and articulate forms. In his figures, trees, cattle, and in everything having a determinate and regular form, his pencil was not only deficient in accuracy of outline, but even in perspective and actual relief. His trees, in particular, frequently seem pasted on the canvass, like botanical specimens. In fine, we cannot subscribe to the opinion of those who assert that Wilson was superior to Claude as a man of genius; nor can we discern any other grounds for this opinion than what would lead to the general conclusion,—that the more slovenly the performance the finer the picture, and that that which is imperfect is superior to that which is perfect. It might be said, on the same principle, that the coarsest sign-painting is better than the reflection of a landscape in a mirror; and the objection that is sometimes made to the mere imitation of nature cannot be made to the landscapes of Claude, for in them the graces themselves have, with their own hands, assisted in selecting and disposing every object. Is the general effect in *his* pictures injured by the details? Is the truth inconsistent with the beauty of the imitation? Does the perpetual profusion of objects and scenery, all perfect in themselves, interfere with the simple grandeur and comprehensive magnificence of the whole? Does the precision with which a plant is marked in the fore-ground take away from the air-drawn distinctions of the blue glimmering horizon? Is there any want of that endless airy space, where the eye wanders at liberty under the open sky, explores distant objects, and returns back as from a delightful journey? There is no comparison between Claude and Wilson. Sir Joshua Reynolds used to say that there would be another Raphael before there would be another Claude. His landscapes have all that is exquisite and refined in art and nature. Every thing is moulded into grace and harmony; and, at the touch of his pencil, shepherds with their flocks, temples and groves, and winding glades and scattered hamlets, rise up in never-ending succession, under the azure sky and the resplendent sun, while

> Universal Pan,
> Knit with the graces, and the hours in dance,
> Leads on the eternal spring.——

Michael Angelo has left, in one of his sonnets, a fine apostrophe to the earliest poet of Italy:

> Fain would I, to be what our Dante was,
> Forego the happiest fortunes of mankind.

What landscape-painter does not feel this of Claude.[1]

[1] This painter's book of studies from nature, commonly called *Liber Veritatis*, disproves the truth of the general opinion, that his landscapes are mere artificial compositions; for the finished pictures are nearly fac-similes of the original sketches.

We have heard an anecdote connected with the reputation of Gainsborough's pictures, which rests on pretty good authority. Sir Joshua Reynolds, at one of the academy dinners, speaking of Gainsborough, said to a friend, "He is undoubtedly the best English landscape-painter." "No," said Wilson, who overheard the conversation; "he is not the best landscape painter, but he is the best portrait painter in England." They were both wrong; but the story is creditable to the versatility of Gainsborough's talents.

Those of his portraits which we have seen are not in the first rank. They are, in a good measure, imitations of Vandyke, and have more an air of gentility than of nature. His landscapes are of two classes or periods, his early and his later pictures. The former are minute imitations of nature, or of painters who imitated nature, such as Ruysdael, &c., some of which have great truth and clearness. His later pictures are flimsy caricatures of Rubens, who himself carried inattention to the details to the utmost limit that it would bear. Many of Gainsborough's later landscapes may be compared to bad water-colour drawings, washed in by mechanical movements of the hand, without any communication with the eye. The truth seems to be, that Gainsborough found there was something wanting in his *early manner*, that is, something beyond the literal imitation of the details of natural objects; and he appears to have concluded rather hastily, that the way to arrive at that *something more* was to discard truth and nature altogether. His fame rests principally, at present, on his fancy pieces, cottage children, shepherd boys, &c. These have often great truth, great sweetness, and the subjects are often chosen with great felicity. We too often find, however, even in his happiest efforts, a consciousness in the turn of the limbs, and a pensive languor in the expression, which is not taken from nature. We think the gloss of art is never so ill bestowed as on such subjects, the essence of which is simplicity. It is, perhaps, the general fault of Gainsborough, that he presents us with an ideal common life, of which we have had a surfeit in poetry and romance. His subjects are softened and sentimentalized too much; it is not simple unaffected nature that we see, but nature sitting for her picture. Our artist, we suspect, led the way to that masquerade style, which piques itself on giving the air of an Adonis to the driver of a hay cart, and models the features of a milk-maid on the principles of the antique. His *Woodman's Head* is admirable. Nor can too much praise be given to his *Shepherd Boy in a Storm*, in which the unconscious simplicity of the boy's expression, looking up with his hands folded and with timid wonder,—the noisy chattering of a magpie perched above,—and the rustling of the coming storm in the branches of the trees,—produce a most delightful and romantic impression on the mind.

Gainsborough was to be considered, perhaps, rather as a man of delicate taste, and of an elegant and feeling mind, than as a man of genius; as a lover of the art rather than an artist. He devoted himself to it, with a view to amuse and soothe his mind, with the ease of a gentleman, not with the severity of a professional student. He wished to make his pictures, like himself, amiable; but a too constant desire to please almost unavoidably leads to affectation and effeminacy. He wanted that vigour of intellect which perceives the beauty of truth; and thought that painting was to be gained, like other mistresses, by flattery and smiles. It was an error which we are disposed to forgive in one, around whose memory, both as an artist and a man, many fond recollections, many vain regrets, must always linger.[1]

The authority of Sir Joshua Reynolds, both from his example and instructions, has had, and still continues to have, a considerable influence on the state of art in this country. That influence has been, on the whole, unquestionably beneficial in itself, as well as highly creditable to the rare talents and elegant mind of Sir Joshua; for it has raised the art of painting from the lowest state of degradation,—of dry, meagre, lifeless inanity,—to something at least respectable, and bearing an affinity to the rough strength and bold spirit of the national character. Whether the same implicit deference to his authority, which has helped to advance the art thus far, may not, among other causes, limit and retard its future progress,—whether there are not certain original errors, both in his principles and practice, which, the farther they are proceeded in, the farther they will lead us from the truth,—whether there is not a systematic bias from the right line, by which alone we can arrive at the goal of the highest perfection,—are questions well worth considering.

We shall begin with Sir Joshua's merits as an artist. There is one error which we wish to correct at setting out, because we think it important. There is not a greater or more unaccountable mistake than the supposition that Sir Joshua Reynolds owed his success or excellence in his profession to his having been the first who introduced into this country more general principles of the art, and who raised portrait to the dignity of history, from the low drudgery of copying the peculiarities, meannesses, and details of individual nature, which was all that had been attempted by his immediate predecessors. This is so far from being true, that the very reverse is the fact. If Sir Joshua did not give these details and peculiarities so much as might be wished, those who went before him did not give them at all. Those pretended general principles of the art, which, it is said, "alone give value and dignity to it," had been pushed to their extremest absurdity before his time; and it was in getting rid of the mechanical systematic monotony and *middle forms*, by the help of which Lely, Kneller, Hudson, the French painters, and others, carried on their manufactories of history and face painting, and in returning (as far as he did return) to the truth and force of individual nature, that the secret both of his fame and fortune lay. The pedantic servile race of artists whom Reynolds superseded, had carried the abstract principle of improving on nature to such a degree of refinement, that they left it out altogether, and confounded all the varieties and irregularities of form, feature, character, expression, or attitude, in the same artificial mould of fancied grace and fashionable insipidity. The portraits of Kneller, for example, seem all to have been turned in a machine; the eye-brows are arched as if by a compass, the mouth curled, and the chin dimpled; the head turned on one side, and the hands placed in the same affected position. The portraits of this mannerist, therefore, are as like one another as the dresses which were then in fashion, and have the same "dignity and value" as the full bottomed wigs which graced their originals. The superiority of Reynolds consisted in his being varied and natural, instead of being artificial and uniform. The spirit, grace, or dignity which he added to his portraits, he borrowed from nature, and not from the ambiguous quackery of rules. His feeling of truth and nature was too strong to permit him to adopt the unmeaning style of

[1] The idea of the necessity of improving upon nature, and giving what was called a *flattering likeness*, was universal in this country fifty years ago, so that Gainsborough is not to be so much blamed for tampering with his subjects.

Kneller and Hudson; but his logical acuteness was not such as to enable him to detect the verbal fallacies and speculative absurdities which he had learned from Richardson and Coypel; and, from some defects in his own practice, he was led to confound negligence with grandeur. But of this hereafter.

Sir Joshua Reynolds owed his vast superiority over his contemporaries to incessant practice and habitual attention to nature, to quick organic sensibility, to considerable power of observation, and still greater taste in perceiving and availing himself of those excellences of others which lay within his own walk of art. We can by no means look upon Sir Joshua as having a claim to the first rank of genius. He would hardly have been a great painter if other greater painters had not lived before him. He would not have given a first impulse to the art; nor did he advance any part of it beyond the point where he found it. He did not present any new view of nature, nor is he to be placed in the same class with those who did. Even in colour, his pallet was spread for him by the old masters; and his eye imbibed its full perception of depth and harmony of tone from the Dutch and Venetian schools rather than from nature. His early pictures are poor and flimsy. He indeed learned to see the finer qualities of nature through the works of art, which he, perhaps, might never have discovered in nature itself. He became rich by the accumulation of borrowed wealth, and his genius was the offspring of taste. He combined and applied the materials of others to his own purpose with admirable success; he was an industrious compiler or skilful translator, not an original inventor, in art. The art would remain, in all its essential elements, just where it is if Sir Joshua had never lived. He has supplied the industry of future plagiarists with no new materials. But it has been well observed, that the value of every work of art, as well as the genius of the artist, depends not more on the degree of excellence than on the degree of originality displayed in it. Sir Joshua, however, was perhaps the most original imitator that ever appeared in the world; and the reason of this, in a great measure, was, that he was compelled to combine what he saw in art with what he saw in nature, which was constantly before him. The portrait painter is, in this respect, much less liable than the historical painter to deviate into the extremes of manner and affectation; for he cannot discard nature altogether under the excuse that *she only puts him out.* He must meet her face to face; and if he is not incorrigible, he will see something there that cannot fail to be of service to him. Another circumstance which must have been favourable to Sir Joshua was, that though not the originator *in point of time*, he was the first Englishman who transplanted the higher excellences of his profession into his own country, and had the merit, if not of an inventor, of a reformer, of the art. His mode of painting had the graces of novelty in the age and country in which he lived; and he had, therefore, all the stimulus to exertion which arose from the enthusiastic applause of his contemporaries, and from a desire to expand and refine the taste of the public.

To an eye for colour and for effects of light and shade, Sir Joshua united a strong perception of individual character,—a lively feeling of the quaint and grotesque in expression, and great mastery of execution. He had comparatively little knowledge of drawing, either as it regarded proportion or form. The beauty of some of his female faces and figures arises almost entirely from their softness and fleshiness. His pencil wanted firmness and precision. The expression, even of his best portraits, seldom implies either lofty or impassioned intellect or delicate sensibility. He also wanted grace, if grace requires simplicity. The mere negation of stiffness and formality is not grace; for looseness and distortion are not grace. His favourite attitudes are not easy and natural, but the affectation of ease and nature. They are violent deviations from a right line. Many of the figures in his fancy pieces are placed in postures in which they could not remain for an instant without extreme difficulty and awkwardness. We might instance the *Girl drawing with a Pencil*, and some others. His portraits are his best pictures, and of these his portraits of men are the best; his pictures of children are the next in value. He had fine subjects for the former, from the masculine sense and originality of character of many of the persons whom he painted; and he had also a great advantage, as far as practice went, in painting a number of persons of every rank and description. Some of the finest and most interesting are those of Dr Johnson, Goldsmith (which is, however, too much a mere sketch), Baretti, Dr Burney, John Hunter, and the inimitable portrait of Bishop Newton. The elegant simplicity of character, expression, and drawing, preserved throughout the last picture, even to the attitude and mode of handling, discover the true genius of a painter. We also remember to have seen a print of Thomas Warton, than which nothing could be more characteristic or more natural. These were all Reynolds' intimate acquaintances, and it could not be said of them that they were men of "no mark or likelihood." Their traits had probably sunk deep into the artist's mind; he painted them as pure studies from nature, copying the real image existing before him, with all its known characteristic peculiarities; and, with as much wisdom as good-nature, sacrificing the graces on the altar of friendship. They are downright portraits and nothing more, and they are valuable in proportion. In his portraits of women, on the contrary, with very few exceptions, Sir Joshua appears to have consulted either the vanity of his employers or his own fanciful theory. They have not the look of individual nature, nor have they, to compensate the want of this, either peculiar elegance of form, refinement of expression, delicacy of complexion, or gracefulness of manner. Vandyke's attitudes have been complained of as stiff and confined. Reynolds, to avoid this defect, has fallen into the contrary extreme of negligence and contortion. His female figures which aim at gentility, are twisted into that serpentine line, the idea of which he ridiculed so much in Hogarth. Indeed Sir Joshua, in his *Discourses* (see his account of Correggio), speaks of grace as if it were nearly allied to affectation. Grace signifies that which is pleasing and natural in the posture and motions of the human form, as beauty is more properly applied to the form itself. That which is stiff, inanimate, and without motion, cannot, therefore, be graceful; but to suppose that a figure, to be graceful, need only be put into some languishing or extravagant posture, is to mistake flutter and affectation for ease and elegance.

Sir Joshua's children, as we have said above, are among his *chef d'œuvres.* The faces of children have in general that want of precision of outline, that prominence of relief and strong contrast of colour, which were peculiarly adapted to his style of painting. The arch simplicity of expression, and the grotesque character which he has given to the heads of his children, were, however, borrowed from Correggio. His *Puck* is the most masterly of all these; and the colouring, execution, and character, are alike exquisite. The single figure of the *Infant Hercules* is also admirable. Many of those to which his friends have suggested historical titles are mere common portraits or casual studies. Thus the *Infant Samuel* is an innocent little child saying its prayers at the bed's feet: it has nothing to do with the story of the Hebrew prophet. The same objection will apply to many of his fancy pieces and

historical compositions. There is often no connection between the picture and the subject but the name. Even his celebrated Iphigenia, beautiful as she is, and prodigal of her charms, does not answer to the idea of the story. In drawing the naked figure, Sir Joshua's want of truth and firmness of outline became more apparent; and his mode of laying on his colours, which in the face and extremities was relieved and broken by the abrupt inequalities of surface and variety of tints in each part, produced a degree of heaviness and opacity in the larger masses of flesh-colour, which can indeed only be avoided by extreme delicacy or extreme lightness of execution.

Shall we speak the truth at once? In our opinion, Sir Joshua did not possess either that high imagination, or those strong feelings, without which no painter can become a poet in his art. His larger historical compositions have been generally allowed to be most liable to objection in a critical point of view. We shall not attempt to judge them by scientific or technical rules, but make one or two observations on the character and feeling displayed in them. The highest subject which Sir Joshua has attempted was the *Count Ugolino*, and it was, as might be expected from the circumstances, a total failure. He had, it seems, painted a study of an old beggar-man's head; and some person, who must have known as little of painting as of poetry, persuaded the unsuspecting artist that it was the exact expression of Dante's Count Ugolino, one of the most grand, terrific, and appalling characters in modern fiction. Reynolds, who knew nothing of the matter but what he was told, took his good fortune for granted, and only extended his canvass to admit the rest of the figures. The attitude and expression of Count Ugolino himself are what the artist intended them to be, till they were pampered into something else by the officious vanity of friends—those of a common mendicant at the corner of a street, waiting patiently for some charitable donation. The imagination of the painter took refuge in a parish work-house, instead of ascending the steps of the Tower of Famine. The hero of Dante is a lofty, high-minded, and unprincipled Italian nobleman, who had betrayed his country to the enemy, and who, as a punishment for his crime, is shut up with his four sons in the dungeon of the citadel, where he shortly finds the doors barred against him, and food withheld. He in vain watches with eager feverish eye the opening of the door at the accustomed hour, and his looks turn to stone; his children one by one drop down dead at his feet; he is seized with blindness, and, in the agony of his despair, he gropes on his knees after them,

> ..... Calling each by name
> For three days after they were dead.

Even in the other world he is represented with the same fierce, dauntless, unrelenting character, "gnawing the skull of his adversary, his fell repast." The subject of the *Laocoon* is scarcely equal to that described by Dante. The horror *there* is physical and momentary; in the other, the imagination fills up the long, obscure, dreary void of despair, and joins its unutterable pangs to the loud cries of nature. What is there in the picture to convey the ghastly horrors of the scene, or the mighty energy of soul with which they are borne? His picture of *Macbeth* is full of wild and grotesque images; and the apparatus of the witches contains a very elaborate and well-arranged inventory of dreadful objects. His Cardinal Beaufort is a fine display of rich mellow colouring; and there is something gentlemanly and Shakspearian in the king and the attendant nobleman. At the same time we think the expression of the cardinal himself is too much one of physical horror, a canine gnashing of the teeth, like a man strangled. This is not the best style of history. Mrs Siddons as the *Tragic Muse* is neither the tragic muse nor Mrs Siddons; and we have still stronger objections to *Garrick between Tragedy and Comedy.*

There is a striking similarity between Sir Joshua Reynolds' theory and his practice; and as each of these has been appealed to in support of the other, it is necessary that we should examine both. Sir Joshua's practice was generally confined to the illustration of that part of his theory which relates to the more immediate imitation of nature; and it is to what he says on this subject that we shall chiefly direct our observations at present.

He lays it down as a general and invariable rule, that "*the great style in art, and the most* PERFECT IMITATION OF NATURE, *consists in avoiding the details and peculiarities of particular objects.*" This sweeping principle he applies almost indiscriminately to *portrait, history,* and *landscape;* and he appears to have been led to the conclusion itself, from supposing the imitation of particulars to be inconsistent with general rule and effect. It appears to us that the highest perfection of the art depends, not on separating, but on uniting general truth and effect with individual distinctness and accuracy.

First, It is said that the great style in painting, as it relates to the immediate imitation of external nature, consists in avoiding the details of particular objects. It consists neither in giving nor avoiding them, but in something quite different from both. Any one may avoid the details. So far there is no difference between the *Cartoons* and a common sign painting. Greatness consists in giving the larger masses and proportions with truth;—this does not prevent giving the smaller ones too. The utmost grandeur of outline, and the broadest masses of light and shade, are perfectly compatible with the utmost minuteness and delicacy of detail, as may be seen in nature. It is not, indeed, common to see both qualities combined in the imitations of nature, any more than the combination of other excellences; nor are we here saying to which the principal attention of the artist should be directed; but we deny that, considered in themselves, the absence of the one quality is necessary or sufficient to the production of the other.

If, for example, the form of the eye-brow is correctly given, it will be perfectly indifferent to the truth or grandeur of the design, whether it consists of one broad mark, or is composed of a number of hair-lines arranged in the same order. So, if the lights and shades are disposed in fine and large masses, the *breadth* of the picture, as it is called, cannot possibly be affected by the filling up of those masses with the details, that is, with the subordinate distinctions which appear in nature. The anatomical details in Michael Angelo, the ever-varying outline of Raphael, the perfect execution of the Greek statues, do not destroy their symmetry or dignity of form; and in the finest specimens of the composition of colour we may observe the largest masses combined with the greatest variety in the parts of which those masses are composed.

The *gross* style consists in giving no details, the *finical* in giving nothing else. Nature contains both large and small parts, both masses and details; and the same may be said of the most perfect works of art. The union of both kinds of excellence, of strength with delicacy, as far as the limits of human capacity and the shortness of human life would permit, is that which has established the reputation of the most successful imitators of nature. Farther, their most finished works are their best. The predominance, indeed, of either excellence in the best masters has varied according to their opinion of the relative value of these qualities,—the labour they had the time or the patience to bestow on their works,—the skill of the artist,—or the nature and extent of his subject.

But if the rule here objected to, that the careful imitation of the parts injures the effect of the whole, be once admitted, slovenliness would become another name for genius, and the most unfinished performance be the best. That such has been the confused impression left on the mind by the perusal of Sir Joshua Reynolds' *Discourses*, is evident from the practice as well as conversation of many (even eminent) artists. The late Mr Opie proceeded entirely on this principle. He left many admirable studies of portraits, particularly in what relates to the disposition and effect of light and shade; but he never finished any of the parts, thinking them beneath the attention of a great artist. He went over the whole head the second day as he had done the first, and therefore made no progress. The picture at last, having neither the lightness of a sketch nor the accuracy of a finished work, looked coarse, laboured, and heavy. Titian is the most perfect example of high finishing. In him the details are engrafted on the most profound knowledge of effect, and attention to the character of what he represented. His pictures have the exact look of nature, the very tone and texture of flesh. The variety of his tints is blended into the greatest simplicity. There is a proper degree both of solidity and transparency. All the parts hang together; every stroke tells, and adds to the effect of the rest. Sir Joshua seems to deny that Titian finished much, and says that he produced, by two or three strokes of his pencil, effects which the most laborious copyist would in vain attempt to equal. It is true, he availed himself in some degree of what is called *execution*, to facilitate his imitation of the details and peculiarities of nature; but it was to facilitate, not to supersede it. There can be nothing more distinct than execution and daubing. Titian, however, made a very moderate, though a very admirable, use of this power; and those who copy his pictures will find that the simplicity is in the results, not in the details. To conclude our observations on this head, we will only add, that while the artist thinks there is any thing to be done, either to the whole or to the parts of his picture, which can give it still more the look of nature, if he is willing to proceed, we would not advise him to desist. This rule is the more necessary to the young student, for he will relax in his attention as he grows older. And again, with respect to the subordinate parts of a picture, there is no danger that he will bestow a disproportionate degree of labour upon them, because he will not feel the same interest in copying them, and because a much less degree of accuracy will serve every purpose of deception.

Secondly, With regard to the imitation of expression, we can hardly agree with Sir Joshua, that "the perfection of portrait painting consists in giving the general idea or character without the individual peculiarities." No doubt, if we were to choose between the general character and the peculiarities of feature, we ought to prefer the former. But they are so far from being incompatible with, that they are not without some difficulty distinguishable from, each other. There is a general look of the face, a predominant expression arising from the correspondence and connection of the different parts, which it is of the first and last importance to give, and without which no elaboration of detached parts, or marking of the peculiarities of single features, is worth any thing; but which, at the same time, is not destroyed, but assisted, by the careful finishing, and still more by giving the exact outline, of each part.

It is on this point that the modern French and English schools differ, and, in our opinion, are both wrong. The English seem generally to suppose, that if they only leave out the subordinate parts, they are sure of the general result. The French, on the contrary, as erroneously imagine, that, by attending successively to each separate part, they must infallibly arrive at a correct whole; not considering that, besides the parts, there is their relation to each other, and the general expression stamped upon them by the character of the individual, which to be seen must be felt; for it is demonstrable, that all character and expression, to be adequately represented, must be perceived by the mind, and not by the eye only. The French painters give only lines and precise differences, the English only general masses and strong effects. Hence the two nations reproach one another with the difference of their styles of art,—the one as dry, hard, and minute,—the other as gross, gothic, and unfinished; and they will probably remain for ever satisfied with each other's defects, as they afford a very tolerable fund of consolation on either side.

Much has been said of *historical portrait;* and we have no objection to this phrase, if properly understood. The giving historical truth to a portrait means, then, the representing the individual under one consistent, probable, and striking view; or showing the different features, muscles, &c. in one action, and modified by one principle. A portrait thus painted may be said to be *historical;* that is, it carries internal evidence of truth and propriety with it; and the number of individual peculiarities, as long as they are true to nature, cannot lessen, but must add to, the strength of the general impression.

It might be shown, if there were room in this place, that Sir Joshua has constructed his theory of the *ideal* in art upon the same mistaken principle of the negation or abstraction of *particular nature.* The *ideal* is not a negative, but a positive thing. The leaving out the details or peculiarities of an individual face does not make it one jot more ideal. To paint history, is to paint nature as answering to a general, predominant, or preconceived idea in the mind, of strength, beauty, action, passion, thought, &c.: but the way to do this is not to leave out the details, but to incorporate the general idea with the details; that is, to show the same expression actuating and modifying every movement of the muscles, and the same character preserved consistently through every part of the body. Grandeur does not consist in omitting the parts, but in connecting all the parts into a whole, and in giving their combined and varied action: abstract truth or ideal perfection does not consist in rejecting the peculiarities of form, but in rejecting all those which are not consistent with the character intended to be given, and in following up the same *general idea* of softness, voluptuousness, strength, activity, or any combination of these, through every ramification of the frame. But these modifications of form or expression can only be learnt from nature, and therefore the perfection of art must always be sought in nature. The ideal properly applies as much to the *idea* of ugliness, weakness, folly, meanness, vice, as of beauty, strength, wisdom, magnanimity, or virtue. The antique heads of fauns and satyrs, of Pan or Silenus, are quite as ideal as those of the Apollo or Bacchus; and Hogarth adhered to an idea of humour in his faces, as Raphael did to an idea of sentiment. But Raphael found the character of sentiment in nature as much as Hogarth did that of humour, otherwise neither of them would have given one or the other with such perfect truth, purity, force, and keeping. Sir Joshua Reynolds' *ideal*, as consisting in a mere negation of individuality, bears just the same relation to real beauty or grandeur as caricature does to true comic character.

It is owing either to a mistaken theory of elevated art, or to the want of models in nature, that the English are

Fine Arts.

hitherto without any painter of serious historical subjects, who can be placed in the first rank of genius. Many of the pictures of modern artists have shown a capacity for correct and happy delineation of actual objects and domestic incidents only inferior to the masterpieces of the Dutch School. We might here mention the names of Wilkie, Collins, Heaphy, and many others. We have portrait-painters who have attained to a very high degree of excellence in all the branches of their art. In landscape, Turner has shown a knowledge of the effects of air, and of powerful relief in objects, which was never surpassed. But in the highest walk of art—in giving the movements of the finer or loftier passions of the mind, this country has not produced a single painter who has made even a faint approach to the excellence of the great Italian painters. We have, indeed, a good number of specimens of the clay-figure, the anatomical mechanism, the regular proportions measured by a two-foot rule;—large canvasses, covered with stiff figures, arranged in deliberate order, with the characters and story correctly expressed by uplifted eyes or hands, according to old receipt-books for the passions; and with all the hardness and inflexibility of figures carved in wood, and painted over in good strong body colours, that look "as if some of nature's journeymen had made them, and not made them well." But we still want a Prometheus to give life to the cumbrous mass,—to throw an intellectual light over the opaque image,—to embody the inmost refinements of thought to the outward eye,—to lay bare the very soul of passion. That picture is of little comparative value which can be completely *translated* into another language,—of which the description in a common catalogue conveys all that is expressed by the picture itself; for it is the excellence of every art to give what can be given by no other in the same degree. Much less is that picture to be esteemed which only injures and defaces the idea already existing in the mind's eye,—which does not come up to the conception which the imagination forms of the subject, and substitutes a dull reality for high sentiment; for the art is in this case an incumbrance, not an assistance, and interferes with, instead of adding to, the stock of our pleasurable sensations. But we should be at a loss to point out, we will not say any English picture, but certainly any English painter, who, in heroic and classical composition, has risen to the height of his subject, and answered the expectation of the well-informed spectator, or excited the same impression by visible means as had been excited by words or by reflection.[1] That this inferiority in English art is not owing to a deficiency of genius, imagination, or passion, is proved sufficiently by the works of our poets and dramatic writers, which, in loftiness and force, are not surpassed by those of any other nation. But whatever may be the depth of internal thought and feeling in the English character, it seems to be *more internal;* and, whether this is owing to habit or physical constitution, to have comparatively a less immediate and powerful communication with the organic expression of passion,—which exhibits the thoughts and feelings in the countenance, and furnishes matter for the historic muse of painting. The English artist is instantly sensible that the flutter, grimace, and extravagance of the French physiognomy, are incompatible with high history; and we are at no loss to explain in this way, that is, from the defect of living models, how it is that the productions of the French school are marked with all the affectation of national caricature, or sink into tame and lifeless imitations of the antique. May we not account satisfactorily for the general defects of our own historic productions in a similar way,—from a certain inertness and constitutional phlegm, which does not habitually impress the workings of the mind in correspondent traces on the countenance, and which may also render us less sensible of these outward and visible signs of passion, even when they are so impressed there? The irregularity of proportion and want of symmetry in the structure of the national features, though it certainly enhances the difficulty of infusing natural grace and grandeur into the works of art, rather accounts for our not having been able to attain the exquisite refinements of Grecian sculpture, than for our not having rivalled the Italian painters in expression.

Mr West formed no exception to, but a confirmation of, these general observations. His pictures have all that can be required in what relates to the composition of the subject; to the regular arrangement of the groups; the anatomical proportions of the human body; and the technical knowledge of expression,—as far as expression is reducible to abstract rules, and is merely a vehicle for the telling of a story; so that anger, wonder, sorrow, pity, &c. have each their appropriate and well-known designations. These, however, are but the instrumental parts of the art, the means, not the end; but beyond these Mr West's pictures do not go. They never "snatch a grace beyond the reach of art." They exhibit the *mask,* not the *soul,* of expression. We doubt whether, in the entire range of Mr West's productions, meritorious and admirable as the design and composition often are, there is to be found one truly fine head. They display a total want of gusto. In Raphael, the same divine spirit breathes through every part; it either agitates the inmost frame, or plays in gentle undulations on the trembling surface. Whether we see his figures bending with all the blandishments of maternal love, or standing in the motionless silence of thought, or hurried into the tumult of action, the whole is under the impulse of deep passion. But Mr West saw hardly any thing in the human face but bones and cartilages; or, if he availed himself of the more flexible machinery of nerves and muscles, it was only by rule and method. The effect is not that which the soul of passion impresses on the countenance, and which the soul of genius alone can seize; but such as might, in a good measure, be given to wooden puppets or pasteboard figures, pulled by wires, and taught to open the mouth, or knit the forehead, or raise the eyes in a very scientific manner. In fact, there is no want of art or learning in his pictures, but of nature and feeling.

Means of promoting the fine arts.

It is not long ago since an opinion was very general, that all that was wanting to the highest splendour and perfection of the arts in this country might be supplied by academies and public institutions. There are *three* ways in which academies and public institutions may be supposed to promote the fine arts; either by furnishing the best models to the student, or by holding out immediate emolument and patronage, or by improving the public taste. We shall bestow a short consideration on the influence of each.

First, a constant reference to the best models of art necessarily tends to enervate the mind, to intercept our view of nature, and to distract the attention by a variety of unattainable excellence. An intimate acquaintance with the works of the celebrated masters may indeed add to the indolent refinements of taste, but will never produce one work of original genius, one great artist. In proof of the general truth of this observation, we might

[1] If we were to make any qualification of this censure, it would be in favour of some of Mr Northcote's compositions from early English history.

cite the history of the progress and decay of art in all countries where it has flourished. It is a little extraordinary, that if the real sources of perfection are to be sought in schools, in models, and public institutions, that wherever schools, models, and public institutions have existed, there the arts should regularly disappear,—that the effect should never follow from the cause.

The Greek statues remain to this day unrivalled,—the undisputed standard of the most perfect symmetry of form. In Italy the art of painting has had the same fate. After its long and painful struggles in the time of the earlier artists, Cimabue, Ghirlandaio, Massacio, and others, it burst out with a light almost too dazzling to behold, in the works of Titian, Michael Angelo, Raphael, and Correggio; which was reflected with diminished lustre in the productions of their immediate disciples, lingered for a while with the school of the Carraccis, and expired with Guido Reni. From that period painting sunk to so low a state in Italy as to excite only pity or contempt. There is not a single name to redeem its faded glory from utter oblivion. Yet this has not been owing to any want of Dilettanti and Della Cruscan societies,—of academies of Florence, of Bologna, of Parma, and Pisa,—of honorary members and foreign correspondents—of pupils and teachers, professors and patrons, and the whole busy tribe of critics and connoisseurs.

What is become of the successors of Rubens, Rembrandt, and Vandyke? What have the French academicians done for the arts; or what will they ever do, but add intolerable affectation and grimace to centos of heads from the antique, and caricature Greek forms by putting them into opera attitudes? Nicholas Poussin is the only example on record in favour of the contrary theory, and we have already sufficiently noticed his defects. What extraordinary advances have we made in our own country in consequence of the establishment of the royal academy? What greater names has the English school to boast than those of Hogarth, Reynolds, and Wilson, who created it?

Again, we might cite, in support of our assertion, the works of Carlo Maratti, of Raphael Mengs, or of any of the effeminate school of critics and copyists, who have attempted to blend the borrowed beauties of others in a perfect whole. What do they contain, but a negation of every excellence which they pretend to combine? The assiduous imitator, in his attempts to grasp all, loses his hold of that which was placed within his reach; and, from aspiring at universal excellence, sinks into uniform mediocrity. The student who has models of every kind of excellence constantly before him, is not only diverted from that particular walk of art in which, by patient exertion, he might have obtained ultimate success, but, from having his imagination habitually raised to an overstrained standard of refinement, by the sight of the most exquisite examples in art, he becomes impatient and dissatisfied with his own attempts, determines to reach the same perfection all at once, or throws down his pencil in despair. Thus the young enthusiast, whose genius and energy were to rival the great masters of antiquity, or create a new era in the art itself, baffled in his first sanguine expectations, reposes in indolence on what others have done,—wonders how such perfection could have been achieved,—grows familiar with the minutest peculiarities of the different schools,—flutters between the splendour of Rubens and the grace of Raphael, and ends in nothing. Such was not Correggio. He saw and felt for himself; he was of no school, but had his own world of art to create. That image of truth and beauty which existed in his mind he was forced to construct for himself, without rules or models. As it had arisen in his mind from the contemplation of nature, so he could only hope to embody it to others by the imitation of nature. We can conceive the work growing under his hands by slow and patient touches, approaching nearer to perfection, softened into finer grace, gaining strength from delicacy, and at last reflecting the pure image of nature on the canvass. Such is always the true progress of art; such are the necessary means by which the greatest works of every kind have been produced. They have been the effect of power gathering strength from exercise, and warmth from its own impulse —stimulated to fresh efforts by conscious success, and by the surprise and strangeness of a new world of beauty opening to the delighted imagination. The triumphs of art were victories over the difficulties of art; the prodigies of genius, the result of that strength which had grappled with nature. Titian copied even a plant or a piece of common drapery from the objects themselves; and Raphael is known to have made elaborate studies of the principal heads in his pictures. All the great painters of this period were thoroughly grounded in the first principles of their art; had learned to copy a face, a hand, or an eye, and had acquired patience to finish a single figure before they undertook to paint extensive compositions. They knew that though fame is represented with her head above the clouds, her feet rest upon the earth. Genius can only have its full scope where, though much may have been done, more remains to do; where models exist chiefly to show the deficiencies of art, and where the perfect idea is left to be filled up in the painter's imagination. When once the stimulus of novelty and of original exertion is wanting, generations repose on what has been done for them by their predecessors, as individuals, after a certain period, rest satisfied with the knowledge they have already acquired.

With regard to the pecuniary advantages arising from the public patronage of the arts, the plan unfortunately defeats itself; for it multiplies its objects faster than it can satisfy their claims, and raises up a swarm of competitors for the prize of genius from the dregs of idleness and dulness. The real patron is anxious to reward merit, not to encourage gratuitous pretensions to it; to see that the man of genius *takes no detriment*, that another Wilson is not left to perish for want;—not to propagate the breed of embryo candidates for fame. Offers of public and promiscuous patronage can in general be little better than a species of intellectual seduction, administering provocatives to vanity and avarice, and leading astray the youth of the nation by fallacious hopes, which can scarcely ever be realized. At the same time, the good that might be done by private taste and benevolence is in a great measure defeated. The moment that a few individuals of discernment and liberal spirit become members of a public body, they are no longer anything more than parts of a machine, which is usually wielded at will by some officious overweening pretender; their good sense and good nature are lost in a mass of ignorance and presumption; their names only serve to reflect credit on proceedings in which they have no share, and which are determined on by a majority of persons who have no interest in the arts but what arises from the importance attached to them by regular organization, and no opinions but what are dictated to them by some self-constituted judge. As far as we have had an opportunity of observing the conduct of such bodies of men, instead of taking the lead of public opinion, of giving a firm, manly, and independent tone to that opinion, they make it their business to watch all its caprices, and follow it in every casual turning. They dare not give their sanction to sterling merit struggling with difficulties, but take advantage of its success to reflect credit on their own reputation for sagacity. Their taste is a servile dependent on their vanity, and their patronage

has an air of pauperism about it. Perhaps the only public patronage which was ever really useful to the arts, or worthy of them, was that which they received first in Greece, and afterwards in Italy, from the religious institutions of the country; when the artist felt himself, as it were, a servant at the altar; when his hand gave a visible form to gods or heroes, angels or apostles; and when the enthusiasm of genius was exalted by mingling with the flame of national devotion. The artist was not here degraded by being made the dependent on the caprice of wealth or fashion, but felt at once the servant and the benefactor of the public. He had to embody, by the highest efforts of his art, subjects which were sacred to the imagination and feelings of the spectators; there was a common link, a mutual sympathy, between them in their common faith. Every other mode of patronage but that which arises either from the general institutions and manners of a people, or from the real unaffected taste of individuals, must, we conceive, be illegitimate, corrupted in its source, and either ineffectual or injurious to its professed object.

Lastly, Academies and institutions may be supposed to assist the progress of the fine arts, by promoting a wider taste for them.

In general, it must happen in the first stages of the arts, that as none but those who had a natural genius for them would attempt to practise them, so none but those who had a natural taste for them would pretend to judge of or criticise them. This must be an incalculable advantage to the man of true genius; for it is no other than the privilege of being tried by his peers. In an age when connoisseurship had not become a fashion,—when religion, war, and intrigue, occupied the time and thoughts of the great,—only those minds of superior refinement would be led to notice the works of art, who had a real sense of their excellence; and, in giving way to the powerful bent of his own genius, the painter was most likely to consult the taste of his judges. He had not to deal with pretenders to taste, through vanity, affectation, and idleness. He had to appeal to the higher faculties of the soul,—to that deep and innate sensibility to truth and beauty, which required only fit objects to have its enthusiasm excited,—and to that independent strength of mind, which, in the midst of ignorance and barbarism, hailed and fostered genius wherever it met with it. Titian was patronized by Charles V. Count Castiglione was the friend of Raphael. These were true patrons and true critics; and, as there were no others (for the world, in general, merely looked on and wondered), there can be little doubt that such a period of dearth of factitious patronage would be most favourable to the full development of the greatest talents, and to the attainment of the highest excellence.

By means of public institutions, the number of candidates for fame and pretenders to criticism is increased beyond all calculation, while the quantity of genius and feeling remains much the same as before; with these disadvantages, that the man of original genius is often lost among the crowd of competitors who would never have become such but from encouragement and example, and that the voice of the few whom nature intended for judges is apt to be drowned in the noisy and forward suffrages of shallow smatterers in taste. (D. D.)

ARTS, Master of. See Degrees, Academical.

ARVALES Fratres, in *Roman Antiquity*, a college of twelve priests, instituted by Romulus, and chosen out of the most noble families, he himself being one of that body. They assisted in the sacrifices of the ambervalia, annually offered to Ceres and Bacchus for the prosperity of the fruits of the earth, when they wore on their heads crowns made of ears of corn. The original of this institution was as follows: Acca Laurentia, Romulus's nurse, was accustomed once a year to make a solemn sacrifice for a blessing on the fields, her twelve sons always assisting her in the solemnity; but at last losing one of her sons, Romulus offered himself to supply his place, and gave this small society the name of *Arvales Fratres*. This order was in great repute at Rome: they held the dignity for life, and never lost it on account of imprisonment, banishment, or any other accident.

ARVIL Supper, a feast or entertainment made at funerals in the north part of England. Arvil bread is the bread delivered to the poor at funeral solemnities.

ARVIRAGUS, an ancient British king, who flourished in the time of the emperor Domitian. He gained a complete victory over Claudius; but being soon after besieged in the city of Winchester, he made a treaty with the Romans, and married the emperor's daughter Genuissa. This monarch lived to a good old age: he confirmed the ancient laws, enacted new ones, and liberally rewarded persons of merit.

ARUNDEL, a borough and market-town in the rape of the same name, in the county of Sussex, 57 miles from London. It is a well-built town, on the river Arun. Adjoining to it is the magnificent castle of the dukes of Norfolk, lately repaired and fitted up at a vast expense. The market is on a Saturday. It returns two members to Parliament, chosen by the householders, who commonly pay the compliment to the duke of Norfolk of accepting one on his recommendation. The population was, in 1801, 1855; in 1811, 2178; and in 1821, 2511.

Arundel, *Thomas*, archbishop of Canterbury in the reigns of Richard II., Henry IV., and Henry V., was the second son of Robert, earl of Arundel and Warren, and brother of Richard, earl of Arundel, who was beheaded. At 22 years of age, from being created archbishop of Taunton, he was raised to the bishopric of Ely, on the 6th of April 1375, in the reign of Edward III. He was a great benefactor to the church and palace of this see: among other donations, he gave a curious table of massy gold, adorned with precious stones, which had been given by the king of Spain to Prince Edward, and sold by him to Bishop Arundel. In 1386 he was appointed lord chancellor of England; two years after he was translated to the see of York; and in 1396 was advanced to the archiepiscopal see of Canterbury, when he resigned the chancellorship. This was the first instance of the translation of an archbishop of York to the see of Canterbury. Scarcely was he fixed in this see, when he had a contest with the university of Oxford about the right of visitation. The affair was referred to King Richard, who determined it in favour of the archbishop. At his visitation in London he revived an old constitution, by which the inhabitants of the respective parishes were obliged to pay to their rector one halfpenny in the pound out of the rent of their houses. In the second year of his translation, a parliament being held at London, the commons, with the king's leave, impeached the archbishop, together with his brother the earl of Arundel, and the duke of Gloucester, of high treason. The archbishop was sentenced to be banished, and within forty days to depart the kingdom on pain of death. He retired, first to France, and then to the court of Rome, where Pope Boniface IX. gave him a kind reception. He was engaged in the plot to depose Richard and place the duke of Lancaster on the throne; and re-

turning to England along with him, he was restored to his see on that monarch's accession. In the first year of this prince's reign Arundel summoned a synod, which sat at St Paul's. The next year the commons moved that the revenues of the church might be applied to the service of the public; but Arundel opposed the measure with such vigour that it was thrown aside. In the year 1408 Arundel began to exert himself against the Lollards or Wickliffites; and his zeal for suppressing that sect carried him to several unjustifiable severities against the heads of it, particularly against Sir John Oldcastle and Lord Cobham. He also procured a synodical constitution, which forbade the translation of the Scriptures into the vulgar tongue. This prelate died at Canterbury on the 20th February 1413, of an inflammation in his throat, with which he was seized, as is pretended, whilst he was pronouncing sentence upon Lord Cobham. He was buried in the cathedral church of Canterbury, near the west end, under a monument erected by himself in his lifetime.

ARUNDELIAN MARBLES, OXFORD MARBLES, or PARIAN CHRONICLE, are ancient stones, as has been supposed, whereon is inscribed a chronicle of the city of Athens, engraven in capital letters in the island of Paros, one of the Cyclades, 264 years before Jesus Christ. They take their first name from Thomas, earl of Arundel, who procured them out of the east, or from Henry his grandson, who presented them to the university of Oxford.

The Arundelian marbles, in their perfect state, contained a chronological detail of the principal events of Greece during a period of 1318 years, beginning with Cecrops, before Christ 1582 years, and ending with the archonship of Diognetus, before Christ 264. But the chronicle of the last 90 years is lost, so that the part now remaining ends at the archonship of Diotimus, 354 years before the birth of Christ; and in this fragment the inscription is at present so much corroded and effaced, that the sense can only be discovered by very learned and industrious antiquaries, or, more properly speaking, supplied by their conjectures.

This chronicle, and many other relics of antiquity, real or pretended, were purchased in Asia Minor, in Greece, or in the islands of the archipelago, by Mr William Petty, who, in the year 1624, was sent by Thomas, earl of Arundel, for the purpose of making such collections for him in the east. They were brought into England about the beginning of the year 1629, and placed in the gardens belonging to Arundel house in London.

Soon after their arrival they excited a general curiosity, and were viewed by many inquisitive and learned men, among others by Sir Robert Cotton, who prevailed upon Selden to employ his abilities in explaining the Greek inscriptions. Selden and two of his friends, Patrick Young, or, as he styled himself in Latin, *Patricius Junius*, and Richard James, immediately commenced their operations, by cleaning and examining the marble containing the Smyrnean and Magnesian league, and afterwards proceeded to the Parian chronicle. The following year Selden published a small volume in quarto, including about 39 inscriptions copied from the marbles.

In the turbulent reign of Charles I. and the subsequent usurpation, Arundel house was often deserted by the illustrious owners; and, in their absence, some of the marbles were defaced and broken, and others either stolen or used for the ordinary purposes of architecture. The chronological marble, in particular, was unfortunately broken and defaced. The upper part, containing 31 epochas, is said to have been worked up in repairing a chimney in Arundel house.

In the year 1667 the Honourable Henry Howard, afterwards duke of Norfolk, the grandson of the first collector, presented these supposed remains of antiquity to the university of Oxford.

Selden's work becoming very scarce, Bishop Fell engaged Mr Prideaux to publish a new edition of the inscriptions, which was printed at Oxford in 1676. In 1732 Mr Maittaire obliged the public with a more comprehensive view of the marbles than either of his predecessors. Lastly, Dr Chandler published a new and improved copy of the marbles in 1763, in which he corrected the mistakes of the former editors; and in some of the inscriptions, particularly that of the Parian chronicle, supplied the *lacunæ* by many ingenious conjectures.

The Arundelian marbles have generally been regarded as a curious monument of antiquity. They were, however, discovered in some instances to be inconsistent with the most authentic historical accounts. Sir Isaac Newton and several other modern philosophers paid little or no regard to them; and their absolute authenticity has been severely questioned in an express dissertation upon the subject by Mr Robertson, published in 1788, entitled *The Parian Chronicle*. In this dissertation much ingenuity as well as learning is displayed. His doubts, the author observes, arise from the following considerations.

I. "The characters have no certain or unequivocal marks of antiquity." The Π and Z, which frequently occur in the form supposed to be the most ancient (viz. the perpendicular line of the Π on the right hand only half as long as that on the left, and the Z in the form of a prostrate Ξ), are so well known, that any modern fabricator of a Greek inscription which he intends to impose upon the world as a relic of antiquity would most probably use them in preference to the more common and ordinary forms. But the letters in the Parian chronicle have no appearance of antiquity except this very equivocal one. They do not in the least resemble the Sigean, the Nemean, or the Delian inscriptions, which are supposed to be of a more ancient date. They differ in many respects from the letters on the Marmor Sandvicense, which, according to the learned editor of that inscription, was engraved in the year before Christ 374. They bear no sort of resemblance to the characters on the Farnesian pillars, to those of the Alexandrian manuscript, or others of a later date. They seem, continues our author, to resemble, perhaps more than any other, the letters of the alphabet taken by Montfaucon from the Marmor Cyzicenum at Venice. They are plain and simple in their form, and such as an ordinary stone-cutter of the present age would probably make if he were employed to engrave a Greek inscription according to the alphabet now in use. The small letters intermixed among the larger have, in the opinion of our author, an air of affectation and artifice rather than genuine antiquity; and he is persuaded that the antiquity of an inscription can never be proved by the mere form of the letters, because the most ancient characters may be as easily counterfeited as those which compose our present alphabets.

That the learned reader may form a competent idea of the characters in the Parian chronicle, the author has compared them with those of other inscriptions, and given what is usually termed a *fac simile*.

In regard to several *archaisms*, as they are called in this chronicle, and which our author specifies, he contends that no conclusion can be drawn from them in favour of its antiquity. What reason could there be, he asks, for introducing these into the Parian chronicle? We do not usually find them in Greek writers of the same age, or even in those of the most early date. The reign of Ptolemy Philadelphus, with the 21st year of which the date of the chronicle coincides, was not an age of rude antiquity with respect to the Greek language, being only 130 years after

Arundelian Marbles.

the time of Xenophon and Plato, when the Greek was spoken and written in its utmost purity and elegance; and we can scarcely suppose that even a stone-cutter in that refined age would have been permitted to disgrace a superb and learned monument with such barbarisms as occur in the chronicle. The archaisms, however, he remarks, are not uniformly observed in this inscription. He adduces six instances of deviation, and adds, he is almost tempted to suspect that εμ Παρω, εμ Μαραθωνι, and other pretended archaisms, are owing to a mere affectation of antiquity, or to a corrupted dialect and pronunciation in later ages. Those archaisms, our author acknowledges, appear on other marbles; but he thinks that for that very reason they would naturally be adopted by the fabricator of a supposititious inscription; and the authenticity of those inscriptions in which they appear must be established before they can be urged in opposition to the present argument.

II. "It is not probable that the chronicle was engraved for *private use*." Our author thinks it an impossible supposition that such an expensive and cumbersome work could have been executed by a private citizen, either for his own amusement or for the benefit of his fellow-citizens. In the first place, a long inscription could not be engraved in marble without such an expense as few learned Greeks were able to afford; or if its author, by an uncommon felicity, was able to erect such a literary monument, the scheme would have been useless and imprudent, as all the contents of the inscription might have been published more commodiously and effectually by the common mode of writing in use at that time.

III. "The chronicle does not appear to have been engraved by *public authority*."

1*st*, The first argument in support of this opinion is, that inscriptions of that kind usually begin with a particular form, as Η ΒΟΥΛΗ ΚΑΙ Ο ΔΗΜΟΣ. *The senate and the people;* or thus, ΕΔΟΞΕΝ ΤΗΙ ΒΟΥΛΗΙ ΚΑΙ ΤΟΙ ΔΗΜΩΙ, *It pleased the senate and the people*, &c. But the Parian chronicle begins in the manner of a private man, speaking of his own performance in the first person singular. This argument, our author remarks, cannot be much affected by observing that the beginning of the inscription is obliterated; for it is necessarily implied by the words now remaining.

2*dly*, The facts and dates which are mentioned in this chronicle do not appear to have been extracted from any public records, or calculated to answer the purpose of authentic documents, as many eminent princes and magistrates are passed over without notice, in several instances the transactions of whole centuries are omitted, and the facts chiefly specified are not matters of general or national importance.

3*dly*, The Parian inscription is such a one as we can hardly suppose the magistrates or the people of Paros would have ordered to be engraved. Stately sepulchres, pillars, triumphal arches, and the like, were erected to perpetuate the glory of eminent men. The remembrance of events in which nations were interested, the succession of princes, &c. were preserved in the same manner. Leagues, decrees, and laws, were likewise engraved on marble or brass, and fixed to a pillar, the walls of a temple, or other public buildings; because such inscriptions were designed for the inspection of the people, as they essentially concerned their conduct, their property, their liberty, or their lives. But our author asks, for whom could the chronicle of Paros be intended? It contains no encomiums on any of the patriots, the heroes, or the demigods of the country, no decrees of the magistrates, no public records, no laws of state. On the contrary, it is a work of mere speculation and learning, in which the inhabitants of that island, especially the common people, had not the least interest or concern.

These words at the beginning, αρχοντος εμ Παρω, would naturally lead us to suppose that the inscription related to Paros. And if so, it would have been natural for the author to have mentioned some of the most important occurrences in the history of that island. But, says this acute and learned critic, what scheme does our chronologer pursue on this occasion? Does he record the events and revolutions of his own country? Does he mention any of the battles, sieges, and treaties of the Parians; any of their public institutions; any of their poets, patriots, or warriors? Does he mention Archilochus, who was honoured by his countrymen, and distinguished as a poet in a general assembly of the Greeks? Not a syllable on any of these subjects! On the contrary, he rambles from place to place, and records the transactions of Athens, Corinth, Macedon, Lydia, Crete, Cyprus, Sicily, Persia, and other foreign countries with which Paros had no connection.

In this view the inscription seems to have been as impertinent in the island of Paros as a marble monument would be in this country recording the antiquities of France or Spain; or one in Jamaica recording the revolutions of England. But, upon supposition that the inscription is a forgery, it is easy to account for this extraordinary circumstance. A few chronological occurrences in the ancient history of Paros would not have been so interesting to the generality of readers, or so valuable in the estimation of every lover of antiquities, or, in short, so profitable to the compiler, as a general system of Grecian chronology.

IV. "The Greek and Roman writers, for a long time after the date of this work, complain that they had no chronological account of the affairs of ancient Greece." This position is confirmed by the testimony of Julius Africanus, Justin Martyr, Plutarch, Josephus, Varro, Diodorus Siculus, and others; and the following series of interrogatories is subjoined:—"Thucydides, I know, lived 140 years before the chronicle is said to have been written; but if Thucydides, as well as other writers, complained that there was nothing but uncertainty in the earlier part of Grecian history, from whence can we suppose the author of this inscription collected such a clear, determinate, and comprehensive system of chronology? If he had any sources of information which were unknown to succeeding writers, how happens it that they should all of them overlook this most considerable, most exact, most creditable author? Why did they omit this ancient account of their early ages? Why did they not copy his most memorable epochas? Why did they not produce his authority? or, at least, why did they not mention his opinion? Surely nothing, to all appearance, could be more elaborate, more important, or of higher authority, than a chronological table which was thought worthy of being engraved on marble.

V. "The chronicle is not once mentioned by any writers of antiquity." This, indeed, appears a strong argument against its authenticity. Apollodorus, an Athenian, the disciple of Aristarchus the grammarian, and Panætius the philosopher, wrote a genealogical and historical work on the early ages of Greece; but though composed 120 years after the date of the Parian chronicle, it does not contain the smallest traces of a systematical chronology. It is remarkable, too, that the chronicle of Apollodorus is quoted by Diodorus Siculus, Strabo, Plutarch, A. Gellius, Lucian, and many other writers of antiquity; while the Parian chronicle, which comprehends a more extensive period, is entirely unnoticed. It contains, however, such wonderful discoveries in ancient history, that if it had ex-

isted 264 years before the Christian era, it must have excited a general attention, and been referred to as an authority by writers of succeeding times. But we do not find, in any author of antiquity, either poet or historian, geographer or chronologer, mythologist or scholiast, the most distant allusion to the Parian chronicle; though it was such a common practice among the ancients to mention the works of their predecessors, that in many books we find references and allusions to three, four, five, six, or seven hundred different authors of every denomination.

VI. "Some of the facts mentioned in the chronicle seem to have been taken from writers of a later date." Our inquirer collates several passages in the Parian chronicle with parallel passages in Greek authors, to evince that there is, in the former, an appearance of imitation, or a stronger resemblance than such as may be supposed to arise from accident; that there are likewise some improbabilities attending the account of Deucalion, as related in the Parian chronicle; and that the names of six, and, if the *lacunæ* are properly supplied, the names of twelve cities appear to have been engraved on the marble, exactly as we find them in Ælian's *Various History*. But there is not, our author observes, any imaginable reason for this particular arrangement. It does not correspond with the time of their foundation, with their situation in Ionia, with their relative importance, or with the order in which they are placed by other eminent historians. The argument by which our author endeavours to prove that the Parian chronicle has in this instance copied Ælian's *Various History*, seems decisive of the fact. He observes that six names may be transposed 720 different ways, and that 12 names admit of 479,001,600 different transpositions. Supposing, then, that there is no particular reason for one arrangement rather than another, it will follow that the chance of two authors placing them in the same order is, in the former case, as 1 to 720; and, in the latter, as 1 to 479,001,600. It is therefore, says he, utterly improbable that these names should have been placed in this order on the marble, if the author of the inscription had not transcribed them from the historian.

It may indeed be urged, with regard to this similarity of arrangement in the Parian chronicle and Ælian's *Various History*, that the inference might be the very inverse of that which is specified by our author. But that Ælian should have seen the Parian chronicle without once mentioning it, or that he should have exactly copied a list of towns, arranged neither according to chronological or topographical order, is indeed a supposition equally improbable with the other.

VII. "Parachronisms appear in some of the epochas, which we can scarcely suppose a Greek chronologer in the 129th olympiad would be liable to commit." After specifying these, our inquirer asks, would a writer of reputation and learning, in one of the most polished and enlightened eras of ancient Greece, commit such mistakes, in opposition to the positive attestations of the most accurate historians, in events of public notoriety? Would a private citizen or a magistrate of Paros order a crude and inaccurate series of epochas to be engraved at a great expense, and transmitted to posterity on a marble monument? It is hardly probable.

VIII. "The history of the discovery of the Parian chronicle is obscure and unsatisfactory." Our author observes that it is attended with some suspicious circumstances, and without any of those clear and unequivocal evidences which always discriminate truth from falsehood. There are no data in the inscription by which to discover the place where the marble was erected. The place likewise where it was found is not ascertained, though the generality of writers who have had occasion to mention it have supposed that it was found in the island of Paros. If it was erected at Smyrna, as some imagine, our author asks, for what purpose does the writer mention Astyanax the archon of Paros, and not one circumstance relative to Smyrna? If, adds he, it was erected at Paros, why does he not mention more archons of that city than one? or how shall we account for his profound silence with respect to all the events and revolutions which must have happened in that island, and have been infinitely more interesting to the natives than the transactions of any foreign country?

The train of circumstances by which the Parian chronicle came into the possession of Mr Petty, whom Lord Arundel had sent into the East for the purpose of collecting antiquities, as well as the subsequent conduct of Peiresc, its former owner, affords our author a strong presumption that "the inscription was actually fabricated with the view of obtaining for it a high price, upon the pretence that it was a relic of great antiquity. It is certain that there is something mysterious in the conduct of the first ostensible proprietors. These marbles had been totally unknown or unnoticed for almost 1900 years, and at last are dug out of the ground—nobody can tell us when or where!"

IX. "The literary world has been frequently imposed upon by spurious books and inscriptions, and therefore we should be extremely cautious with regard to what we receive under the venerable name of antiquity." This proposition is illustrated by a great variety of examples, and very properly exposes the forgeries which have disgraced the republic of letters in different ages; and although one of the more recent ones cited, namely, Ossian's *Poems*, be a point very far indeed from being established, yet that deceptions of this kind have been practised is an unquestionable fact.

In endeavouring, towards the end of his Dissertation, to investigate the time of the supposed forgery, he observes that the 16th century, and the prior part of the 17th, produced a multitude of grammarians, critics, and commentators, deeply versed in Grecian literature, and amply qualified for the compilation of such a chronological system as that of the Arundelian marbles. Above all, the science of chronology was particularly studied and investigated about that time: "Nunc fervet chronologia," says Scaliger in the year 1605, "omnes hoc ferrum excalfaciunt." Cassaubon treats those persons with contempt who were unacquainted with the improvements which had been made in that department of learning after the revival of letters. Innumerable systems of chronology had been published before the year 1625, from which it was easy to extract a series of memorable events, and give the compilation a Grecian dress. "The avidity," says our author, "with which all relics of antiquity were then collected, and the high price with which they were purchased, were sufficient inducements to any one, whose avarice or whose necessity was stronger than his integrity, to engrave his labours on marble, and transmit them to Smyrna, as a commodious emporium for such rarities."

The foregoing arguments are no doubt possessed of considerable force and plausibility; but they have been ably answered, and the authenticity of the Parian chronicle vindicated, by other writers; particularly the late Professor Porson, in an examination of Mr Robertson's Dissertation, in the *Monthly Review* for January 1789. See also Hewlett's Vindication, in the *Archæologia*, vol. ix.

ARUSPICES, or HARUSPICES, in *Roman Antiquity*, an order of priests who pretended to foretel future events by inspecting the entrails of victims killed in sacrifice; they were also consulted on occasion of portents and prodigies. The aruspices were also chosen from the best families;

and as their employment was of the same nature as that of the augurs, they were as much honoured. Their college, as well as those of the other religious orders, had its particular registers and records.

ARX, in the ancient military art, a town, fort, or castle, for defence of a place. The arx in ancient Rome was a distinct edifice from the capitol, though some have confounded the two.

Arx also denotes a consecrated place on the Palatine Mount, where the augurs publicly performed their office. Some will have the arx to have been the augural temple, but Varro expressly distinguishes between the two.

Arx was particularly used for a public place in Rome, set apart for the operations of the augurs; in which sense arx amounts to the same with what is otherwise called *auguraculum* and *auguratorium*, and in the camp *augurale*. Out of this arx it was that the *feciales*, or heralds, gathered the grass used in the ceremony of making leagues and treaties.

ARZEW, a seaport in the western part of the kingdom of Algiers, containing very considerable, and sometimes beautiful, remains of antiquity. There are traces of very fine ancient cisterns, though all the water used by the inhabitants is brackish. At the distance of five miles there are very fine salt pits, which serve, however, only for the supply of the neighbouring districts. Long. 1. E. Lat. 35. 52. N.

ARZILLA, a very ancient maritime town of Africa, in the kingdom of Fez, about five leagues from Tangiers. It is built at the mouth of a river, and inhabited by Moors and Jews, who carry on no trade. It was formerly a Roman colony, under the name of Julia Traducta. It afterwards fell under the government of the Goths, and was next taken by the Mahometans. Alphonso of Portugal, surnamed the African, took it by assault in 1471, and brought away the presumptive heir of the crown. After that prince came to the throne, he besieged it in 1508, with 100,000 men; but was obliged to abandon the undertaking. However, at length the Portuguese forsook it of their own accord. It is now sunk into a very small place, not containing above 1000 inhabitants.

AS, in *Antiquity*, a particular weight, consisting of 12 ounces, being the same with *libra*, or the Roman pound. The word is derived from the Greek αις, which, in the Doric dialect, is used for εις, *one*, q. d. an entire thing; though others will have it named *as* quasi *æs*, because made of brass.

As was also the name of a Roman coin, which was of different weight and different matters in different ages of the commonwealth. Under Numa Pompilius, according to Eusebius, the Roman money was either of wood, leather, or shells. In the time of Tullus Hostilius it was of brass, and called *as libra*, *libella*, or *pondo*, because actually weighing a pound or 12 ounces. Four hundred and twenty years after, the first Punic war having exhausted the treasury, they reduced the *as* to two ounces. In the second Punic war, Hannibal pressing very hard upon them, they reduced the *as* to half its weight, viz. to one ounce. And lastly, by the Papirian law they took away half an ounce more, and consequently reduced the *as* to the diminutive weight of half an ounce; and it is generally thought that it continued the same during the commonwealth, and even to the reign of Vespasian. The *as*, therefore, was of four different weights in the commonwealth. Its original stamp was that of a sheep, ox, or sow; but from the time of the emperors it had on one side a Janus with two faces, and on the reverse the rostrum or prow of a ship.

As was also used to denote any integer or whole; whence the English word *ace*. Thus *as* signified the whole inheritance; whence *hæres ex asse*, the heir to the whole estate.

ASA, king of Judah, succeeded his father Abijam. He pulled down the altars erected to idols, restored the worship of the true God, and, with the assistance of Benhadad, king of Syria, took several towns from the king of Israel. He died 917 years before the Christian era, and was succeeded by Jehoshaphat.

ASAPH, St, a small episcopal city in the county of Flint, in North Wales, at the confluence of the rivers Clwd and Elwy, said to have been founded in the year 560. The situation is fine, but the town itself has a poor appearance, the houses being small and ill built. The chief objects are the cathedral, a plain building about 170 feet in length and 90 in height; the bishop's palace, a commodious but simple dwelling; and another church, in which divine service is performed in the Welsh language. The diocese consists of parts of Flintshire, Derbyshire, Montgomeryshire, Merionethshire, and comprehends a few parishes in Shropshire. The deanery, in the gift of the bishop, is a more valuable benefice than the bishopric itself. It is 209 miles from London, and 21 from Chester. No market is held there. Population, in 1801, 1513; in 1811, 1724; in 1821, 2294.

ASAR-ADDON, or Esar-Haddon, the son of Sennacherib, succeeded his father about 712 years before the Christian era, and united the kingdoms of Nineveh and Babylon. He rendered himself master of Syria, sent a colony to Samaria, and his generals took King Manasses, and carried him loaded with chains to Babylon. Asar-Addon died after a reign of 12 years.

ASAROTA, ασαρωτα, from α and σαιρω, *I sweep*, a kind of painted pavements in use before the invention of mosaic work. The most celebrated was that at Pergamus, painted by Sesus, which exhibited the appearance of crumbs, as if the floor had not been swept after dinner; hence, according to Pliny, the denomination. Perrault supposes them to have been a black kind of pavements, of a spongy matter.

ASBESTOS. See Mineralogy.

ASCALON, a town of Palestine, on the sea coast, 14 miles north of Gaza, and 30 south-west of Jerusalem. It was one of the satrapes of Egypt, and was noted during the crusades. It contains some precious remains of antiquity, long streets, and innumerable red granite pillars, mostly fallen. Long. 34. 47. E. Lat. 31. 38. N.

ASCANIUS, the son of Æneas and Crusa, succeeded his father in the kingdom of the Latins, and defeated Mezentius, king of the Tuscans, who had refused to conclude a peace with him. At length he founded Alba Longa, and died about 1139 years before the Christian era, after a reign of 38 years.

ASCENDANT, in *Astrology*, denotes the horoscope, or the degree of the ecliptic which rises upon the horizon at the time of the birth of any one. This is supposed to have an influence on the person's life and fortune, by giving him a bent and propensity to one thing more than another. In the celestial theme this is also called the *first house*, the *angle of the East*, or *Oriental angle*, and the *significator of life*. Such a planet ruled in his *ascendant*, Jupiter was in his *ascendant*, &c. Hence the word is also used in a moral sense for a certain superiority which one man has over another from some unknown cause.

ASCENSION, a solitary island, or rather rock, in the midst of the Atlantic, about 700 or 800 miles from the western coast of Africa. It was discovered in 1501 by Joao de Nova Gallego, a Portuguese navigator, who named it Ilha de Nossa Senhora de Conceiçao. It was seen a second time by Alfonso d'Albuquerque, in his voyage to India in 1503, and then received its present name. As-

Ascension Day. Ascham.

cension consists of a single rocky mountain, though shooting up into several detached peaks, of the most naked and desolate character, consisting in a great measure of volcanic remains. The beach, always beat upon by a heavy surf, is covered with a sand of snowy whiteness, which, when acted upon by the sun, is intolerable to the eyes. The sides of the cliffs consist of lava, variously coloured, and in different stages of decomposition. Easter Island and Terra del Fuego do not present a more dreary aspect. At a considerable height occurs a plain about eight miles in circumference, from the south-east quarter of which there rises a lofty hill, presenting an appearance of verdure not discoverable in any other part of the island. Here is found a grass peculiar to the island, and a few goats are fed, whose flesh is extremely delicate. Notwithstanding the unproductive character of this island, its excellent harbour, and the fish, sea-fowl, and turtle, with which it abounds, have made it a place of refreshment for the homeward-bound shipping. A crevice in one of the rocks has been employed for depositing letters, to be taken up by the next ship passing in a contrary direction, and has been hence called the sailor's post-office. Long. 14. 28. W. Lat. 8. 8. S.

Ascension Day, a festival of the Christian church, held ten days before Whitsuntide, in memory of our Saviour's ascension into heaven after his resurrection.

ASCETERIUM, in ecclesiastical writers, is frequently used for a monastery, or place set apart for the exercise of virtue and religion. The word is formed from *ascesis*, exercise; or *ascetra*, one who performs exercise. Originally it signified a place where the athletæ or gladiators performed their exercises.

ASCETIC, an ancient appellation given to such persons as, in the primitive times, devoted themselves more immediately to the exercises of piety and virtue in a retired life, and particularly to prayer, abstinence, and mortification. The word is derived from ασκεω, *exerceo*, I exercise. Afterwards, when the monks came in fashion, this title was bestowed upon them, especially upon such of them as lived in solitude.

ASCHAFFENBURG, a city in the Bavarian circle of the Lower Maine. It is situated on an elevation above the river Maine, containing eight churches, 755 houses, and 6590 inhabitants. The streets are narrow and crooked, the houses large and antique. Near it the castle, formerly the residence of the prince, is a fine building, with an orangery and pheasantry. There are several institutions for civil and ecclesiastical education. The trade consists in paper and leather made in the city, in building vessels to navigate the river, and in the transit commerce which the long stream creates.

Aschaffenburg, a bailiwick in the circle of the Lower Maine, containing 10,635 inhabitants, in one market-town and 18 villages, besides several small hamlets. It lies on both sides of the Maine, is mountainous and woody, but produces good wine and cider, and feeds many herds of black cattle.

ASCHAM, Roger, a very distinguished scholar and writer, was born at Kirby Wiske, a village in Yorkshire, near Northallerton, about the year 1515. John Ascham, his father, was house-steward in the family of Scroop, and by his wife, Margaret, was connected with several respectable families. A short time before his death, Sir Anthony Winfield, having conceived a predilection for his third son Roger, took him into his family, and extended his bounty so far as to give him the advantage of a private education along with his own sons. Under a domestic tutor he made a rapid progress in classical learning, and early discovered a great partiality for reading. The superiority of genius and docility of temper which he constantly displayed induced his patron to send him to St John's College, Cambridge, in the year 1530.

The revival of Grecian and Roman literature at the period Ascham entered upon his studies was peculiarly favourable to the natural bent of his inclination. A desire of excelling uniformly influenced his conduct, and, adopting the maxim, *Qui docet, discit*, he began to teach boys the rudiments of the Greek language as soon as he was acquainted with the elementary parts himself. His plan was approved by Pember, and under the direction of this valuable friend he soon became acquainted with the best Greek and Latin authors. But he took particular delight in reading Cicero and Cæsar, and upon them formed the elegance of his Latin style, which proved so honourable and so advantageous in the after part of his life.

Ascham took his first degree of bachelor of arts in his 18th year, and was chosen fellow of the college about a month afterwards. The favourable disposition, however, which he manifested towards the reformed religion was no small obstacle in the way of his preferment. He was elected master of arts in the year 1537, and about this period he began to act in the capacity of a tutor.

His reputation for Greek learning soon brought him many pupils; and these were so well instructed that several of them afterwards rose to considerable eminence. Of these William Grindall was one of the most distinguished, who obtained the station of master of languages to the lady Elizabeth, upon the recommendation of Sir John Cheke. It appears uncertain why Ascham himself was not appointed to that honourable station; but his partiality for the university seems, from a hint in one of his letters, to have been the cause. At that period there was no particular chair appropriated to the Greek language, but Ascham was appointed by the university to read lectures upon that language in the schools. A dispute arose in the university at that time about the pronunciation of the Greek language, in which Ascham first opposed the method observed by Sir John Cheke and Sir Thomas Smith; but, upon more mature deliberation, he adopted that method, which has ever since been practised in the English schools. Both on account of the beauty of his handwriting, and the purity and elegance of his Latin, he was employed to write the public letters of the university.

By the advice of his friend Pember, he turned his attention to the study of instrumental music, and thereby enlivened his leisure hours, and prepared his mind for renewed exertion. In his study he also amused himself with embellishing the pages of his manuscripts with beautiful draughts, and in the field he joined in the diversion of the bow and arrow. The learned Ascham did not deem his labour improperly bestowed in writing a book entitled *Toxophilus*, in an age when the proper use of the bow was of more importance than for mere amusement. This work was written in a more natural, easy, and truly English diction than had hitherto been in use; and it also abounds with many beautiful allusions and curious fragments of English history. Ascham candidly acknowledges, that being anxious to make the tour of Italy, which was then the great republic of letters, and particularly of Grecian literature, he wished, by dedicating his book to the king, to obtain a pension, to enable him to make that tour. It reflects some lustre on the benevolence of Henry VIII. that in the year 1544 he settled upon him an annual pension of L.10, which Dr Johnson, considering the circumstances of the times, estimates at the value of L.100. Upon the death of Henry this pension was for some time discontinued; but it was again renewed by Edward VI., and doubled by Queen Mary. In the same year, also, Ascham obtained the ap-

pointment of orator to the university; an office which he retained with great reputation during the period he was connected with the university.

For some years he received an annual gratuity from Lee, archbishop of York, but to what amount is not recorded; and, in 1548, upon the death of his pupil Grindall, preceptor to the lady Elizabeth, his pupils and writings had acquired him such celebrity, that he was appointed to direct the studies of that princess. He successfully acquitted himself in that honourable charge; but two years after, from some unknown cause of dissatisfaction, he returned to the university, having taken an abrupt leave of the princess. This part of his conduct did not lessen him in the esteem of Elizabeth; for in the same year she recalled him to court, and appointed him secretary to Sir Richard Morisine, ambassador to the emperor Charles V. In his way to London he paid a visit to Lady Jane Gray, whom he found in her chamber reading Plato's *Phædo*, in Greek, " and that," says he, " with as much delight as some gentlemen would read a merry tale in Boccace;" while the duke and duchess, and the rest of the household, were hunting in the park.

In the character of secretary to Sir Richard, besides aiding him in the management of his public affairs, he also conducted his private studies. During the mornings of four days in the week he read with him a portion of Herodotus or Demosthenes, and in the evenings some pages of Sophocles or Euripides; and on the other mornings he wrote the letters of public business, and on the evenings he either wrote his own private letters or continued his diary and remarks. While Ascham was on his travels, he made a short excursion to Italy; but was much disgusted with the manners of the people, especially of the Venetians. After his return from that tour, he favoured the world with a curious tract, entitled *A Report and Discourse of the Affairs and State of Germany*, &c.

Upon the death of Edward VI. Morisine was recalled, and Ascham returned to the university. But through the interest of Bishop Gardiner, the fortune of Ascham soon took a favourable turn, who, although he knew him to be a Protestant, obtained him the office of Latin secretary to the queen, with liberty to retain his university emoluments, and the additional salary of L.10 a-year. The prudence of Ascham enabled him to act a respectable part, both under the intolerant reign of Mary, and also in the most perilous situations during the reign of Elizabeth; and the readiness and elegance of his Latin style rendered him a useful member at court. He is reported to have written, during the course of three days, 47 letters to persons in the highest ranks of life.

When the crown passed to a Protestant prince, it made little alteration in the condition of Ascham, who still retained his station. He spent several hours every day in reading the learned languages with the queen, and her proficiency was equal to his labours; and it might have been expected that his rewards would have been more ample than L.20 per annum, together with the prebend of Westwang. Some have alleged that the queen kept him poor because he was addicted to cock-fighting, and in other respects extravagant; but the defects in his character should not have deprived him of the rewards due to actual services.

In consequence of a conversation which took place in the apartment of secretary Cecil, upon the subject of education, Sir Richard Sackville, who was present, requested him to write a book on the general subject of education. This work is entitled *The Schoolmaster*, and contains many excellent instructions to the teachers of youth. It was published by his widow after his death. By too close application to composing a poem, which he intended to present to the queen on the new-year's day of 1569, he was seized with an illness which proved fatal, and died on the 23d of December 1568. His death was universally lamented, and the queen expressed her regret by saying, that " she would rather have lost L.10,000 than her tutor Ascham." His epistles, which are valuable both on account of their style and historical information, were published after his death, and dedicated to the queen: the best edition is that of Mr Elstob, published at Oxford in 1703. His English works were published in 4to, with a life by Dr Johnson, in 1767. This edition has been reprinted in 8vo.

ASCHENDORF, a bailiwick in the circle of Meppen and province of Osnaburg, in the kingdom of Hanover. It lies on the banks of the Ems, and contains two towns and five villages, with 8972 inhabitants, almost wholly Catholics, with many remains of old German habits and prejudices.—The capital of the bailiwick is of the same name, and contains one church, a monastery of Franciscans, and 1177 inhabitants, several of whom are seamen.

ASCHERSLEBEN, a circle in the government of Magdeburg and province of Saxony, in Prussia, formed out of a part of the principality of Halderstadt and the abbey of Quedlinburg. It contains 198 square miles, or 126,720 acres. The population in 1817 amounted to 36,283 persons. The Bode and the Eine are the chief rivers; and on their banks the land is highly fertile, producing great crops of corn, flax, and rape-seed. The city of Quedlinburg is the chief place of the circle.

Aschersleben, a city in the circle of the same name, containing 1178 houses and 8731 inhabitants. It has an extensive trade in friezes, flannels, and other woollen goods, and in linen, leather, tobacco, and rape-oil.

ASCII, among geographers, an appellation given to those inhabitants of the earth who at certain seasons of the year have no shadow: such are all the inhabitants of the torrid zone when the sun is vertical to them.

ASCITÆ (from ασκος, *a bag* or *bottle*), in *Antiquity*, a sect or branch of Montanists, who appeared in the second century. They were so called because they introduced a kind of Bacchanals into their assemblies, who danced round a skin or bag blown up, saying they were those new bottles filled with new wine whereof our Saviour makes mention, Matth. ix. 17. They are sometimes also called *Ascodrogitæ*.

ASCLEPIA, a festival of Æsculapius, the god of physic, observed particularly at Epidaurus, where it was attended with a contest between the poets and musicians, whence it was likewise called Ιερος Αγων, *the sacred contention*.

ASCLEPIAD, in ancient poetry, a verse composed of four feet, the first of which is a spondee, the second a choriambus, and the last two dactyls; or of four feet and a cæsura, the first a spondee, the second a dactyl, after which comes the cæsura, then the two dactyls; as, *Mæcenas atavis edite regibus*.

ASCLEPIADES, one of the most celebrated physicians among the ancients, was a native of Prusa in Bithynia, and practised physic at Rome under Pompey 96 years before the Christian era. He was the head of a new sect; and, by making use of wine and cold water in the cure of the sick, acquired a very great reputation. He wrote several books, which are frequently mentioned by Galen, Celsus, and Pliny; but they do not now exist.

Asclepiades, a famous physician under Adrian, of the same city with the former. He wrote several books concerning the composition of medicines, both internal and external.

ASCODUTÆ, in *Antiquity*, a sect of heretics in the second century, who rejected all use of symbols and sacraments, on this principle, that incorporeal things can-

not be communicated by things corporeal, nor divine mysteries by any thing visible.

ASCOLI, one of the delegations into which the Papal States in Italy are divided. It comprises a part of the ancient mark of Ancona or of Fermo. It is bounded on the north-west and north by Fermo, on the east by the Adriatic Sea, on the south by the territory of Naples, and on the west by Spoleto. The extent is 480 square miles, or 307,200 acres. The Appennines are in part included in this province. It contains 3 cities, 4 market-towns, and 44 villages, with 69,058 inhabitants. The soil is generally fruitful, and the climate salubrious.—The capital of the delegation is of the same name, the see of a bishop, and the tribunal of law. It is situated at the junction of the river Castellano with the Tronto. In the mouth of the latter is a small harbour for coasting vessels. The city contains a cathedral, 12 parish churches, 12 monasteries, 6 nunneries, a Jesuit's college, and 7550 inhabitants. Long. 13. 28. 25. E. Lat. 42. 51. N.

ASCOLIA, in *Grecian Antiquity*, a festival celebrated by the Athenian husbandmen in honour of Bacchus, to whom they sacrificed a he-goat, because it destroys the vines; and, to show the greater indignity to an animal hated by Bacchus, the peasants, after having killed him, made a foot-ball of his skin.

ASCRIPTITII, or ADSCRIPTITII, a kind of serfs, so annexed to the lands that they may be transferred and sold with them. Adscriptitii is sometimes also used in speaking of aliens or foreigners newly admitted to the freedom of a city or country.

ASDRUBAL, the name of several Carthaginian generals. See CARTHAGE.

ASHANTEE, a country in Western Africa, situated in the interior of that part of Guinea called the Gold Coast. It forms now the most powerful of all the kingdoms in that quarter of Africa, and is perhaps the most improved of any among the completely native states which have remained strangers to the Arabic language and Moslem institutions. This kingdom, therefore, possesses now a somewhat peculiar interest, and may deserve to be treated of at some length.

The Ashantee empire, including the numerous districts, once independent, but now entirely reduced under its control and jurisdiction, is considered by M. Dupuis as extending from 5. 0. to 9. 0. N. lat., and from 0. to 4. 0. W. long., and may thus comprise a space of about 50,000 square miles, inhabited by 3,000,000 of people. The original Ashantee, however, occupied by the nation who have subjugated this large extent of territory, is not supposed to include more than a third of this large space, nor to have a population exceeding 1,000,000.

Tradition represents the Ashantees as deriving their origin from numerous bands of emigrants, who, two or three centuries ago, were driven before the Moslem tribes migrating southward from the countries on the Niger and Senegal. The Ashantees having occupied and cleared a region before covered with almost impenetrable forests, defended themselves with a valour which became part of their national character, and which raised them from a band of fugitives to the rank of a powerful and conquering nation. They even subdued and reduced into vassalage several of the Moslem tribes by whom they had been formerly supplanted.

Early in the 18th century the Ashantees first came under the notice of Europeans through the wars in which they engaged with the kingdoms bordering on the maritime territory. Among these, Dinkira is described by Bosman as holding such a pre-eminence in wealth and power, that it looked down with contempt on all the surrounding tribes. Yet Sai Tooto, the king of Ashantee, emboldened by successive conquests, and by the tried valour of his people, hesitated not to encounter this formidable potentate. The war was excited by an insult offered to a member of an embassy sent by the king of Ashantee, consisting, according to a usage prevalent in this part of Africa, of a detachment of his numerous wives. The pride of Dinkira caused its sovereign to refuse all explanation or atonement; and war immediately ensued upon a great scale, each party mustering their allies and tributaries; and successive battles were fought with such fury, that 100,000 men were reported to have fallen on each side. It terminated in the complete overthrow of Dinkira, which had its pride completely humbled, and has continued ever since a mere vassal and tributary of Ashantee.

Sai Tooto may be considered as the real founder of the power of this kingdom. He either built or greatly extended and embellished Coomassie, the capital; he subdued the Mahometan countries of Gaman and Banna, the latter of which has been called the right arm of Ashantee; and he extended the empire by conquests both on the east and west. But it remained still quite an inland state, nowhere approaching the coast nearer than 40 or 50 miles. Finally, Sai Tooto having invaded the country of Akim, when marching at the head of a small detachment to join his army, was surprised and slain. The Ashantees, who held that prince in the highest veneration on account of his justice and valour, were so deeply affected by this catastrophe, that they have ever since distinguished the day by terms expressive of its gloomy character—as the dreadful day—the day of God's chastisement. In fact, it was followed by a temporary anarchy, and by contests for the succession, which encouraged all the vassal kingdoms to throw off the yoke; so that when Sai Apoko in 1731 came into full possession of the throne, the conquests of his predecessor were to be made afresh. However, he did make them: Gaman, Assin, Akim, and Dinkira, were by new victories annexed to the empire more firmly than before, while farther acquisitions gradually opened his way to the coast. Sai Apoko, in the latter part of his reign, involved the kingdom in violent agitation by an attempt to deprive the nobles of their rights and privileges. This gave rise to a serious rebellion, which the king, indeed, triumphantly suppressed; yet on his death, which happened soon after, the chiefs, before raising his successor to the throne, were careful to abrogate these innovations, and regain their wonted share in the administration.

Sai Akwasy, the next sovereign, was chiefly employed in suppressing insurrections which continually arose among the numerous little subject tribes, amounting, it is said, to forty-seven, held in reluctant subjection to his government, and who seized every opportunity to shake off the yoke. The contest with Gaman was waged with various and long doubtful success, but at length it was triumphant. In an attempt, however, to cross the Volta and invade Dahomy, he encountered a complete overthrow; and Ashantee has never again ventured to extend her ambitious views to that fierce and warlike kingdom.

The reigns of Sai Quamina and Sai Apoko II. were not distinguished by any events of great magnitude. In 1800 the throne was mounted by Sai Tooto Quamina, who soon showed himself animated by a peculiar spirit of enterprise and ambition. He appears early to have formed a desire of opening a communication with white nations, and of improving his country by the introduction of their arts and knowledge. Occupied, however, by wars in the countries to the north, and by an insurrection in Gaman, he could not for some time turn his views in that direction. About 1808, however, a dispute arose among the chiefs

of Assin, which the king seems to have made very great efforts to compose in a friendly manner; but, through the violence and rashness of the Assinese, it ended in an open rupture. The insurgent forces were defeated with great slaughter, and the chiefs compelled to seek refuge on the coast among the Fantees, there the ruling people. The king again made overtures of accommodation; but by a strange infatuation the rebel chiefs not only rejected these, but put his messengers to death with every species of outrage. The Ashantee monarch then threw away every remnant of forbearance, and determined that every thing most dreadful in African warfare should be felt by them, and by the Fantees their protectors. The allies found themselves wholly unable to resist the torrent of invasion; the country was laid waste with fire and sword, and they were driven with dreadful slaughter towards the coast. At length the fugitives reached the town of Anamaboe, where there was then a British fort. The governor exhorted the Anamaboes to endeavour to make pacific arrangements with this powerful enemy, and offered his mediation; but the citizens, falsely confident in their own strength, resolved to abide the contest. When a division, however, of the Ashantee army had destroyed the neighbouring town of Cormantine, the inhabitants of which came flying to Anamaboe for refuge, the governor contrived to open a communication with the king, requesting to know the cause of his attacking Anamaboe, and offering to mediate an accommodation. The reply was, that on sending 20 barrels of gunpowder and 100 muskets, the English would be made acquainted with the king's intentions. This reply afforded no opening to negociation; and in fact they learned that the Ashantee chief, on reaching the sea, had shown an extraordinary exultation, having three times dipped his sword into the water. A reconnoitring party, which the enemy in the first instance sent forward, was repulsed, after a hard contest, by the Anamaboes; but on the following day, when the whole force of the invader was brought up, the citizens were seen retreating in the utmost disorder. They found no refuge even in the town, to which they retreated, but were pursued with the most dreadful slaughter to the margin of the sea. The English governor, after receiving into the fort as many of the old men, women, and children, as its walls could contain, vainly endeavoured to repel the enemy by continued discharges of musketry and grape shot. The attempt was fruitless; and after having completely destroyed the town, they advanced against the castle, and made the most desperate efforts to carry it by storm. The situation of the English was critical in the extreme: to oppose a force estimated at 15,000 they had not above 24 men, several of whom were artificers and free mulattoes. The Ashantees continued the attack for several hours, firing with such precision as to cut off every man who appeared at an embrasure, and the garrison was reduced to eight men fit for service. Towards evening, however, the enemy, having been unable to gain an entrance at any point, desisted. Next morning the scene around the fort displayed a dreadful picture of the ravages of barbarous warfare; the houses of the city mostly unroofed or on fire; the shore strewed with numerous dead bodies, against which the waves were dashing; the piteous cries of the women and children who had found refuge within the fort. The enemy, however, showed no haste to renew the attack; and in the afternoon a reinforcement of four officers and twelve men was landed from Cape Coast. The governor then, in pursuance of directions from the commander-in-chief, hoisted a white flag in sign of amnesty, which was received cordially, and even with joyful acclamations. The two soldiers who bore the flag were welcomed and presented with a fat sheep; but it appeared that nothing final could be concluded without a meeting between the king and the chief governor, in which view every effort was used to induce the king to pay a visit to Cape Coast Castle; but he very naturally declined to place himself in the power of those with whom he had just waged so deadly a warfare. Colonel Torrance, the chief governor, then repaired to Anamaboe, and forming a procession as handsome as his numbers admitted, went out and waited on the monarch. The English were dazzled by the splendour and dignity displayed by the retinue of the Ashantee prince, which greatly surpassed all that they had observed on the coast. The great men wore dresses of rich silk, and their swords, axes, flutes, and other instruments, were either of solid gold or profusely adorned with that precious metal. The court etiquette was studied and dignified; each of the great officers gave separate audience, seated under a huge umbrella, and surrounded by numerous attendants. The king, of a deep black complexion, was well formed, with an open and pleasing countenance: he wore a plain silk dress, without any of the golden ornaments with which the inferior captains were loaded. A treaty was concluded, which could not but be satisfactory to the monarch, since, according to M. Dupuis, it included a complete acknowledgment on the part of the governor, that the whole territory of Fantee, including Cape Coast itself, the capital, belonged by right of conquest to the Ashantee empire. The governor took a still more questionable mode of securing the favour of this great potentate. Cheboo and Apoutay, the chiefs with whom this dreadful war originated, had fled to Cape Coast, where they lived under at least the tacit protection of the British government. Now, however, parties were despatched to attack them, who seized Cheboo after a desperate resistance; but Apoutay, beating off the assailants, effected his escape. The former chief was then delivered as a propitiatory offering to the king, by whom he was put to death with cruelty and ignominy.

Although the Ashantees carried all before them in the field, an epidemical disorder, causing a considerable mortality in their army, obliged them to retire. Then the Fantees, according to their usual rash and imprudent course of proceeding, threw off the yoke. This brought down upon them, in 1811, a second expedition, in which the invader met with equal success, and for some time carried all before him; but one of those internal rebellions to which the kingdom was always subject interrupted his career, and obliged him to return. The Fantees, always courageous in the absence of danger, again reared their heads, and prepared for themselves, in 1816, an invasion more formidable than either of the two preceding. They suffered a most disastrous overthrow; Cape Coast was held in long blockade, and the Fantees were finally compelled to own themselves the subjects of the king of Ashantee.

Negociations and war with the English.

The British government, actuated by very enlightened views, felt a wish to cultivate the alliance of this great African potentate, and to open a direct communication with him. They thus hoped not only to secure his friendship and commerce with his territories, but to obtain extensive information respecting the interior of Africa. In 1817, Messrs James, Bowdich, and Hutchison, departed on a mission to Coomassie. They had to penetrate through a country, great part of which was overgrown with dense and entangled woods, the route through which consisted only of a narrow and difficult footpath. These obstacles, joined to an illness with which Mr James was attacked, caused the journey, though extending not more than 100 miles, to employ nearly a month. On their arrival they were considerably dazzled both by the extent and handsome appearance of the city, compared with the

maritime capitals, and also by the wild and brilliant array of the caboceers or great war-chiefs. They were soon introduced to the king, whom they found still more profusely loaded with embellishments, consisting of golden ornaments, beads, and amulets. Yet the strings of human teeth, and the executioner seated with his hatchet on his breast, and his stool clotted with blood, threw into the scene a character truly savage. The monarch received them, however, with that dignified politeness which, unless when overcome by passion, he always studiously maintained. He invited them to the market-place, and gave them a public audience in presence of the chiefs and people. The presents, which consisted chiefly of ornamental fabrics of British manufacture, excited his highest admiration: he carefully, and with an intelligent eye, examined their structure. After one or two of these harmonious interviews, subjects of business came under discussion. The king introduced the subject of certain sums which the British were bound to pay to the native governments, for permission to hold fortified factories; making in a manner the ground-rent of their castles. These sums the Fantees, as the ruling people on the coast, had been accustomed to receive; but the king, as having conquered the whole Fantee territory, claimed them now as due to himself. According to the ideas established in Africa, and indeed to the ordinary rights of conquest, the demand seems to have been legitimate. There had, however, been some misunderstanding: Mr James came unprovided with any instructions to meet this claim, and simply replied that he would refer for instructions to the government at Cape Coast Castle. This appears to have been quite foreign to the understanding and expectations of the monarch, who conceived that they came, as he said, "to make peace and settle all palavers." On finding them wholly unprepared to enter on what he viewed as the main object of discussion, he considered himself insulted; that contempt was thrown upon him, and a determination manifested for war. In vain did Mr James protest that they wished only peace and trade: his passion became always more furious; he called them cheats and liars, then started from his seat, bit his beard, exclaiming, that had a negro brought such a message he would have cut off his head. On seeing matters come to this extremity, the two junior members of the mission, Messrs Bowdich and Hutchison, formed a resolution certainly very imprudent and contrary to diplomatic rule. Conceiving that Mr James, by blind and obstinate adherence to rule, was endangering the English interests, and perhaps even the safety of the mission, they took upon themselves to supersede him, and assume the negociation into their own hands. They conducted it in a manner altogether satisfactory to the king: a treaty was concluded, by which all his demands were granted; and, after a residence of several months, in which they were perfectly well treated, they returned to Cape Coast.

The government at home, though they demurred somewhat to the very irregular course followed by Mr Bowdich and his companion, saw evidently the wisdom of cultivating an intercourse with this powerful African court. They determined to station at his court a fixed resident, and nominated to that station M. Dupuis, who had long filled with credit the important post of British consul at Mogadore. M. Dupuis was sent out with instructions to cultivate to the utmost of his power the friendship of this potent monarch, to promote trade with his dominions, and to open through them an intercourse with the interior.

The new consul, being detained in England by various circumstances, did not arrive at Cape Coast till January 1819. By that time a complete and unfortunate change had taken place in the views of the British local government. They had been gained entirely over to the interest of the Fantees or coast natives, who were constantly on the spot, and possessed eloquence, talents, and address. An insurrection had arisen in the interior of the Ashantee monarchy, respecting which the most exaggerated rumours were spread and listened to with blind credulity. Insulting messages were sent to the king, who was also informed that the natives of Cape Coast were setting his authority at open defiance, and were forming a wall to defend the town. The Fantees, so recently subjected, could not be blamed for endeavouring to procure their own emancipation; but the English, who had so much experience of their weakness, ought by no means to have committed themselves in the quarrel. Under the views which he had formed, however, the governor, on various pretences, prevented M. Dupuis from proceeding on his mission. Yet, while this rash and confident spirit continued in full force, rumours of a very opposite description began to arise, and became so prevalent, that the boldest adherents of the present policy were struck with apprehension. It was now confidently stated that the king had gained a complete victory over the rebels; nay, it began to be rumoured that he was in full march with an army upon Cape Coast. That prince, however, appears to have shown a very considerable disposition to effect an amicable adjustment of differences. A messenger of high rank arrived at the castle, and having produced a little Morocco trunk, drew from it the treaty, which was read over, article by article, and repeated appeals made to the governor on the manner in which it had been violated. He was unable to deny the charges; and the confusion which he could not avoid feeling, with the generally changed aspect of affairs, induced him to assume a much more moderate tone. M. Dupuis was even introduced, and his mission mentioned, with which the messenger seemed much pleased, though he could not, without some special instructions, give him an invitation to proceed to Coomassie. Soon after, an ambassador of much higher rank was announced, and excited a stronger sensation, it being reported that he brought with him an army to enforce compliance. His appearance, however, dissipated these apprehensions: he brought with him indeed a train of twelve hundred persons, but these were partly women and boys; and the assemblage was evidently one of state, not of war. The ambassador, however, brought the ultimatum of the king as to atonement demanded for the breach of fealty committed by the people of the town, and in which they had been supported by the English. After enumerating all the wrongs of which they had been guilty towards his sovereign, he demanded the sum of 1600 ounces of gold from the town, and the same amount from the governor. This last demand was rejected as wholly inadmissible, though there was not the same objection made to equitable compensation being required from the natives. It being then found that the ambassador had brought a welcome to M. Dupuis, the governor, in these urgent circumstances, deemed it wisest to withdraw the interdict hitherto placed upon that gentleman's proceeding to Coomassie, and to place in his hands the task of obtaining the best possible terms from this powerful monarch.

M. Dupuis set out on the 9th February 1820, and on the 28th arrived at Coomassie. He soon obtained a public audience of the king, who received him with dignified politeness. After a few days spent in pompous and unmeaning ceremonies, more confidential meetings took place, and business was entered upon at full length. The king expressed uniformly the utmost indignation at the attempt of the natives to shake off his authority. On one occasion

when he happened to be in peculiarly bad humour, this broke out in a demeanour partaking almost of madness. Raising his voice to its utmost pitch, and assuming a countenance of demoniacal frenzy, he threw himself convulsively back in his chair, clenched his fists, and stretched out his arms and legs, while he bellowed out the most direful imprecations against the natives of Cape Coast, not even excepting those present. The foam all the while flowed down his beard in copious discharges, and the saliva spurted from his mouth upon all around him. He even vociferated, "White men come to my country to trade,—what have they to do with my slaves? *Smitty* (Governor Smith) cheats, and joins the Fantees. The Cape Coast people ought to die. Let me go there, let me have the jaw-bones of Aggry and Deljraaf. I don't want their gold; I want the blood of bad men to wash my stool." Afterwards, however, he made a sort of apology for this violent sally, and in his calmer moods was found reasonable and even conciliatory. He expressed great dissatisfaction with the governor of Cape Coast, but the highest respect for the king, whom he seems even in some degree to have owned as a superior, and called him, of course in mere courtesy, his master; only saying, "for the *blacks*, I am king, and I will be paid or I will kill them." M. Dupuis seems to have proceeded very judiciously, and in a manner at once firm and courteous. The king occasionally showed suspicions of his acting as a spy, and even threw out hints to that effect, with many apologies, however, and representing the idea as having originated with his nobles and chiefs. He seems in general to have been fully convinced of the candour and good faith of the English envoy, who, on his side, recognized fully the monarch's claim to the entire sovereignty of the Gold Coast, including the ground on which the forts stood. This implied the validity of the *notes* of rent, amounting for each to the mighty sum of L.8 a month, which threatened to involve Africa in warfare. The king again dropt entirely the large payment demanded from the governor; and, admitting the plea of their poverty, greatly reduced his requisition from the natives. He agreed likewise that the English should exercise a certain jurisdiction in the immediate vicinity of their forts, even over such of his own subjects as should happen to reside there. Upon these principles, a treaty was drawn up, which adjusted satisfactorily all the differences between the two parties. The king dismissed M. Dupuis with many marks of esteem and kindness, sending along with him two natives of distinction, to proceed as ambassadors to England, with a present of two beautiful leopards.

M. Dupuis now returned to Cape Coast with the agreeable impression of having brought this important and difficult negociation to a fortunate issue. He was deeply disappointed when the governor altogether disowned the treaty, representing it as having betrayed British interests, and as having wantonly transferred to Ashantee the sovereignty of the Gold Coast. At the same time the Fantee party persuaded Sir George Collier to refuse transporting to Britain the ambassadors sent by the king of Ashantee; a conduct which could not but be in the highest degree offensive to that monarch.

M. Dupuis returned to England to represent the particulars to the government; but an entire change meantime took place in the administration of the British affairs in Africa. The African Company were induced to resign the command hitherto held by them over the forts, which were taken entirely into the hands of the crown. The first step adopted in consequence, was to invest Sir Charles M'Carthy with the general government of all this range of coast. The king of Ashantee, though highly indignant at the conduct of the former governor, on learning this alteration, seems to have paused, in hopes of its bringing more conciliatory counsels. The new governor arrived early in 1822; but though he had communicated with M. Dupuis, who earnestly endeavoured to impress him with his own ideas of African politics, Sir Charles soon implicitly adopted the principles and policy of the Fantee natives. He placed the town in a posture of defence, and formed alliances with all the neighbouring tribes, who ranged themselves under his standard. Nothing was heard of the former dreaded conqueror of the Gold Coast, who, it was hoped, had been overawed by the formidable force which the English exhibited. In fact, however, he was busied in preparations of various kinds, collecting troops, making incantations, and determining the lucky or unlucky times of commencing the compaign. At length a negro serjeant in the English service was seized in the great square of Anamaboe, on pretext of some injurious expressions respecting the king; and after being detained for six weeks, seemingly in expectation of some negociation being opened for his release, was beheaded at Denqua. The king then commenced open war, summoning all his vassal princes, and calling upon them "to arm against Britain, to the very fishes of the sea." To Sir Charles he sent notice that his scull would soon adorn the great war-drum of Ashantee. Yet at this very time he made overtures through the Dutch government at Elmina, who had always prudently cultivated his alliance. Messengers sent by each party met at Elmina, and a speech was made on the king's part, when he presented indeed a most formidable list of grievances, yet showed himself willing to impute these to the Fantees and the people of Cape Coast rather than to the English; but this discourse was deemed unworthy of answer.

It behoved now the English to meet in the field the formidable enemy whom they had provoked, and taken no pains to appease. Captain Laing having been sent forward with a reconnoitring detachment, encountered an advanced corps of the enemy and totally defeated it; an exploit which increased the rash confidence now prevalent among the British and their allies. The force which could be depended upon, though small, and consisting in a great measure of the merchants and civil servants of the colony, was imprudently divided. Besides Mr Laing's detachment, the main body was split into two parties, under Sir Charles M'Carthy and Major Chisholm. The former, commanding about 1000 Europeans, was attacked near the boundary stream of the Bossem Pra, by a force of the enemy amounting to 10,000. The English fought for some time with great bravery, till their ammunition failed, when Sir Charles commenced his retreat; but the enemy then succeeded in throwing a large corps on his rear, and thus causing a total and destructive route. Only 50 men, including two officers, Major Ricketts and Lieutenant Erskine, returned to the castle. All the rest, among whom were the chief civil functionaries, paid the penalty of their rash counsels. Respecting their fate, there is only the fatal alternative, that they either fell on the field or perished amid tortures inflicted by this barbarous enemy. The former and milder lot, according to the most probable account, befel Sir Charles, though his bones were carried as a trophy to Coomassie.

The Ashantee army now marched upon Cape Coast, laying waste the country with fire and sword. At that place, however, the detachments of Major Chisholm and Captain Laing had united with the wrecks of the main corps, and prepared for defence with the characteristic vigour and courage of English troops. The king, flushed with victory, made repeated and desperate assaults, but was on each occasion repulsed with great loss; and sickness having made its way into his camp, he at length

Ashantee. broke up and retired to Coomassie. It was supposed that he withdrew only to collect a more formidable force, and renew the invasion. Such a design was frustrated by internal disturbances; and the English having since greatly limited their connection with the Gold Coast, and even withdrawn their garrisons from all the forts except the one at Cape Coast, and having also wisely adopted a more conciliatory policy, the good understanding between the two powers has been happily restored. There is even, we believe, at present, a British resident at Coomassie.

Present state of Ashantee. Ashantee proper, comprising about 14,000 square miles, and a million of inhabitants, presents a dense and almost impenetrable forest, the routes through which consist merely of narrow winding tracts, in which, though it is possible for a man to ride, or a palanquin to be carried, no waggon of any description could pass. The interior country round the towns, however, is cultivated with diligence, the fields being kept very clean, and yielding in abundance grain, yams, vegetables, and fruits. The territory yields also a considerable quantity of gold; and that precious metal is brought in still greater abundance from the regions farther to the north, particularly Gaman, where it occurs not merely in the usual form of gold dust, but in pretty large fragments, mingled in pits with rock and gravel. It is even said that, but for a superstitious idea, which induces the natives to leave the largest deposits untouched, the produce might be much more ample. The Ashantees are skilful in several manufactures, particularly in the great African fabric of cotton, which they weave with a loom differing little from that of Europe. Their pottery and works in gold are also skilful, though surpassed by those produced in the more southern countries.

The government of Ashantee forms a mixture of monarchy with a military aristocracy; the lower orders being held in the most complete thraldom, and liable either to be put to death or sold into slavery at the will of the chiefs. The king carries on all the ordinary administration of the state; but in questions relating to peace or war he is bound to consult the council of the caboceers or captains, which M. Dupuis calls a senate. Each of these caboceers keeps a little court, where he gives audience, and makes a profuse display of barbarous pomp. They wear rich silken robes, curiously interwoven with variously coloured threads; and the most common domestic utensils are of solid gold. Leopards' skins, red shells, elephants' tails, eagle and ostrich feathers, are intermingled with Moorish charms and amulets, and with strings of human teeth and bones. Polygamy is indulged to the most enormous extent. The king has a regular allowance of 3333 wives; but in Africa these princesses are employed variously, as guards, messengers, and even in the humblest services. The crown, as often happens in barbarous countries, descends to the king's sister's son, not to his own offspring.

The Ashantee monarchs, though so extremely ambitious, appear to pay considerable regard to the faith of treaties, seeking always a plausible ground of war; and, even when justly provoked, not usually commencing it without previous overtures of negociation. The barbarous and capricious governments, however, by which they are surrounded, jealous of the Ashantee power, without duly measuring their own strength, afford frequent cause of justifiable invasion. Thus, during the last century the Ashantees have conquered Dinkira, Aquamboe, Aquapim, and Assin, countries which lay between them and the coast, and held the chief sway there on the first arrival of Europeans. Then they reduced the whole of the Gold Coast. During the same period, towards the north and the interior of Africa, they subdued the territories of Gaman, Banna, Tonouma, and Degomba, inhabited chiefly by Moslems, before whom the Ashantees had been at first compelled to recede; but notwithstanding the enmity thus naturally generated, the conquerors wisely extended their full protection to the professors of this faith, and raised them often to equal favour and honour with the natives. The king even had made them believe that he felt some disposition to embrace their faith. Ashantee || Ashbourn.

The darkest feature in the Ashantee character undoubtedly consists in the system of human sacrifice, carried to a truly dreadful extent. It is founded on a wild idea of filial and relative piety, which makes the chiefs fancy it their duty to water with blood the graves of their ancestors, whose rank in the future world will, they imagine, be measured by the number of attendants thus sent along with them. There are two fixed annual periods called the great and little *Adai customs*, at each of which human victims are immolated to a monstrous extent. Still more dreadful is the custom celebrated after the death of the king, or any member of the royal house. When Mr Bowdich was at Coomassie, the monarch, in honour of his mother, had sacrificed no less than 3000 victims. They are chiefly prisoners of war or condemned criminals. The nobility also vie with each other on these occasions in testifying respect by the number whom they immolate; they often rush out, seize the passenger of humble birth, and drag him in for this fatal purpose. Hence, during this awful period, the citizens of Coomassie shut themselves up in their houses, or, if compelled by necessity to go abroad, fly along the streets with trembling speed, every moment in fear of becoming victims to this cruel superstition.

There appears to prevail at this court a very considerable desire to introduce a higher degree of civilization, and to raise the Ashantees in the scale of nations. Conscious of the superiority of Europeans, the monarch shows a peculiar ambition to assimilate his system with theirs. From the first he was anxious to cultivate a connection with the English; and M. Dupuis found him impressed with the most lofty ideas of the power and magnificence of king George. He was then employed in erecting a palace in the European style, under the direction of Dutch architects from Elmina. His subjects were very unskilful in this task, but, by numbers and by loud cries, they endeavoured to compensate for the deficiency of skill: they suggested to Dupuis the odd idea of "a legion of demons attempting in mockery a Babel of modern invention." The interior was meant to be splendidly adorned with gold and ivory; and the king said on another occasion, "I must have every thing suitable, and live like a white king." Perhaps, indeed, there is no quarter where the views entertained for the civilization of Africa could be prosecuted with a fairer chance of success. The people of free barbarous states are turbulent, intractable, attached to their former rude and irregular habits, compared to the indulgence of which a few external accommodations are regarded with great indifference. It is otherwise with an absolute monarch, who, when once inspired with a desire for the refinements and enjoyments of civilization, can enforce their production by the ministry of others, and may thus, in gratifying his own ambition, rapidly introduce among his subjects the elements of improvement and industry. (E.)

ASH-WEDNESDAY, the first day of Lent, supposed to have been so called from a custom in the church, of sprinkling ashes that day on the heads of penitents then admitted to penance.

ASHBOURN, a market-town in the hundred of Wirksworth, and county of Derby. It is 139 miles from London, on the high road to the north-west part of the island. It stands on the small beautiful river Dove, by which

Ashburton || Ashmole.

stream some mills for spinning cotton are turned. There is a good corn market held every Saturday. The population was, in 1801, 2006; in 1811, 2112; and in 1821, 2188; but the parish of Ashbourn is more extensive than the town, and at the last census contained 4708 inhabitants.

ASHBURTON, a market and borough-town in the hundred of Teignbridge, and county of Devon, 191 miles from London and 19 from Exeter. It stands in a valley surrounded on every side by hills, on the great road to Plymouth. The parish-church is in the cathedral form, with a lofty tower and spire. It is one of the four towns in which a court is held for the mining districts. There was formerly an extensive trade in the manufacture of serges, which has declined much of late years. It is an ancient borough, returning two members to Parliament, who are chosen by the freeholders, in number about 200. The market is held on Saturday. The population was, in 1801, 3080; in 1811, 3058; and in 1821, 3403.

ASHBY DE LA ZOUCH, a market-town in the hundred of West Goscote, of the county of Leicester. It is in a fine valley on the borders of Derbyshire, on the river Gilweskaw, and surrounded by a most fertile district. The town is well built. Near it is an ancient castle belonging to the Earls of Huntingdon, and a mineral spring, increasing in celebrity, called Griffydam. There is a large market every Saturday. Population in 1801, 2674; in 1811, 3114; and in 1821, 3403.

ASHES, the fixed residue of combustible substances which remains after they have been burnt.

Several religious ceremonies depend upon the use of ashes. St Jerome relates that the Jews in his time rolled themselves in ashes as a sign of mourning. To repent in sackcloth and ashes is a frequent expression in Scripture for mourning and being afflicted for our sins. A heifer being sacrificed upon the great day of expiation, its ashes were distributed among the people, who made from them a sort of lustral water, which they used in purifications, by sprinkling it on such persons as had defiled themselves by touching a dead body or being present at a funeral (Numb. xix. 17).

The ancient Persians had a sort of punishment for some great criminals, which consisted in executing them in ashes. The criminal was thrown headlong from a tower 50 cubits high, which was filled with ashes to a particular height (2 Macc. xiii. 5, 6). The motion which he used to disengage himself from this place plunged him still deeper into it, and this agitation was further increased by a wheel which stirred the ashes continually about until he was stifled.

ASHFORD, a town in the hundred of Chart, in the county of Kent. It has a market on Tuesday. It is 57 miles from London and 12 from Canterbury, in a district of great fertility, watered by the rivers Esk and Stour. The church is a fine old Gothic edifice, containing a monument to a countess of Athol more than 400 years old. The population was, in 1801, 2151; in 1811, 2532; and in 1821, 2773.

ASHLAR, a term used among builders, by which they mean common or free stones, as they come out of the quarry, of different lengths and thicknesses.

ASHLERING, among builders, signifies quartering, to lath to, in garrets, about two and a half or three feet high, perpendicular to the floor, up to the under side of the rafters.

ASHMOLE, ELIAS, an industrious English antiquary and philosopher of the 17th century, was born at Lichfield in 1617. Having enjoyed the advantages of a country education, he went to London at the age of 16, and resided in the family of James Paget, Esq. one of the barons of the exchequer, and then turned his attention to the law and various branches of literature. In the year 1638 he married, and commenced the business of attorney in London. When the civil war began, he, being then a widower, entered into the king's service in the ordnance department. When residing in the city of Oxford in that capacity, he entered Brazen Nose College, and began the study of natural philosophy, mathematics, and astronomy. Naturally inclined to grave and scientific trifles, he wandered too far into the wilds of astrological imposture, not a little encouraged by several eminent men of that age. From the same cause he entered keenly into the secrets of masonry, and made considerable additions to the history of that sect.

When Worcester was surrendered to the parliament in 1646, Ashmole retired to London, where he became acquainted with the famous astrologers, Moore, Lilly, and Booker. Having removed to Berkshire in the year following, he added the knowledge of botany to his other acquirements. There he became acquainted with lady Mainwaring, a well-jointured widow, whom he married in 1649; and although her estate was sequestrated on account of his loyalty, yet through the interest of Lilly and others he again recovered it, and afterwards settled in London, where his house became the resort of all the curious literati. A taste for chemistry, or rather alchemy, was produced, by his conversation with William Blackhouse; and Ashmole, under a feigned name, published a work upon that subject. The next effort of his industry was a collection of the manuscripts of English alchemy, which he published under the title of *Theatrum Chymicum Britannicum*, in 4to. This work was the effect of great labour and expense; and although it procured him much fame among the learned, yet it was only a collection of *Alchemy*,—he appears to have been ignorant of real chemical knowledge. About this period he began to number among his acquaintances Selden, Oughtred, and Dr Wharton.

The wealth he acquired by his marriage engaged him in several disputes, and the lady herself at last made an attack upon him in chancery, but he was honourably acquitted, and the lady restored to her affectionate husband. His active industry never wearied, and he next attended to the study of antiquity and the investigation of records. Along with Sir W. Dugdale, he about this period traced a Roman road to Lichfield. Abandoning all other pursuits, he began to make preparations for his *History of the Order of the Garter*. Upon a visit to Oxford, he gave a full description of the coins bequeathed to that university by Laud; and about this time John Tradescant, the famous gardener of Lambeth, presented him with the collection of curiosities which both he and his father had procured.

Upon the restoration, Ashmole was greatly respected by the king, who made him Windsor herald, and employed him to give a description of the royal medals. The offices of commissioner and comptroller of excise were conferred upon him; and being called to the bar in the Middle Temple, he was afterwards admitted a fellow of the Royal Society. The university of Oxford conferred upon him the degree of doctor of physic; and several other employments and emoluments were given him, until he rose to the highest eminence in the literary world. About this time his second wife died, and he married the daughter of his friend Sir W. Dugdale. In May 1662 he addressed his great work to the king, entitled *The Institution, Laws, and Ceremonies of the most noble Order of the Garter;* folio, London, 1672. In favour of his brother-in-law Mr Dugdale, he resigned his office of herald of Windsor; and when offered the office of garter king-at-arms, he declined it in favour of Sir W. Dugdale. About this time a fire broke out in one of the chambers of the temple

adjacent to his, and consumed a library which he had been collecting during the course of 33 years, together with 9000 coins and many valuable antiquities; but his manuscripts and gold medals fortunately were saved. In 1683 he sent his manuscripts and curiosities to the university of Oxford, which laid the foundation of the *Musæum Ashmoleanum*, still in Oxford. On the death of Sir W. Dugdale, he refused a second time the office which that gentleman had enjoyed. He died at the age of 76, and was interred in the church of Great Lambeth.

ASHRUFF, an ancient and formerly splendid city of Persia, adorned with a magnificent palace built by Shah Abbas, which was his favourite residence. It is situated on the shore of a bay, on the southern coast of the Caspian Sea. This palace is described in glowing terms by Hanway, who saw it in its splendour. It was visited by Fraser in 1821, who found it a heap of ruins; and the town appeared to have suffered equally with the royal establishment. Ashruff was formerly said to have 300 baths within its walls; but it now contains only 500 houses, which are thinly scattered through an extensive jungle. It is about 70 miles west of Astrabad. Long. 53. 15. E. Lat. 36. 50. N.

ASHTON-UNDER-LINE, a large parish in the hundred of Salford and county of Lancaster, distant 5 miles from Manchester and 185 from London. It is one of those large places which within a few years has risen to wealth and populousness from the cotton manufactories. It is situated on the river Tame, and has the benefit of a navigable canal to Manchester, Rochdale, and Lancaster. The parish contains the hamlets of Hartshead, Hay, Moreley, and Staley Bridge. Population in 1801, 15,632; in 1811, 19,052; and in 1821, 25,967.

A S I A.

THIS division of the globe is distinguished by its vast extent; by the striking character of its interior geography; above all by the stupendous revolutions of which it has been the scene; and, lastly, by the high antiquity of its civilization, of which we can still faintly trace the precious remains. Stretching from the southern hemisphere into the northern regions of perpetual winter, it comprises within its bounds the opposite extremes of heat and cold; all the varieties consequently of the animal and vegetable tribes; and that still more interesting variety which the irresistible law of climate impresses on the human species. The surface of Asia, towering to its height far above the regions of perpetual snow, presents, when superficially examined, a confused mass of lofty mountains, diverging into an endless variety of inferior ridges, apparently without plan or system. But a more attentive survey discloses, amid the bold irregularities of nature, the same order and unity of design in the structure of this great continent, as in all the other works of creation.

Asia was the earliest abode of the human race; and, when all the other parts of the world were either uninhabited or sunk in barbarism, it was the seat of great empires and of flourishing and splendid cities, of commerce, of literature, and of all the arts of civilized life. But its early prosperity was blighted by the ruthless devastations of war; its populous cities were utterly destroyed, so that the spot on which many of them stood is now only marked by masses of ruins; their arts and literature have perished; and in such fragments of their writing as still survive, all meaning is buried under the impenetrable veil of an ancient and unknown character. In touching on the various topics which are comprehended under the designation of Asia, it must be remembered that in the following article we are to confine our attention to such general views of its geography, history, institutions, policy, and manners, as will not supersede a more particular description of its various states under their respective designations.

The name of Asia was at first applied by Homer and others of the ancient poets and historians to a small district of Lydia, occupied by a tribe called Asiones, who inhabited a city of the name of Asia. The Greeks, gradually enlarging their discoveries in those eastern countries, still retained the original name, until it embraced the whole of Asia Minor and the countries to the east; and it was at last applied to all the vast regions which subsequent discoveries have brought to light.

The limits of Asia are in some cases marked out by nature, and admit of no dispute; in other parts they are not very clearly defined, and have been differently settled by geographers, according to their own notions of propriety or distinctness. The modern innovation or improvement of erecting the Indian Archipelago and the numerous islands scattered over the Pacific Ocean into a fifth division of the globe, under the title of Australásia, has given rise to some difficulties in fixing the limits of the continent on the south-east. According to some, the Philippines, the Moluccas, the Celebes, Borneo, Java, and Sumatra, should still be included within the boundaries of Asia, leaving on the east the islands of Papua and New Holland to form the western limits of Australasia. Others, however, are for giving the whole Indian Archipelago to Australasia, on the ground that there can be no possible reason for detaching the Philippines and the other islands from the chain of which they evidently form a part, and assigning them to Asia; that they form one entire mass, which presents no natural point of separation; and that on this account the passage between the Philippine Islands and Formosa and the Straits of Malacca constitutes the most natural boundary of Asia on the east. According to this division, all the islands to the east and south of this line, as far as New Zealand and the Society Islands, would belong to Australasia, the continent of which, or the principal mass of land, would be formed by the immense island of New Holland. But this division, simple and distinct though it may appear, has not been generally adopted by geographers, who have assigned for the western boundary of Asia a line passing from Kerguelen's Land to the north-east, cutting off on the west the islands of Timorlaut, Ceram, Mysol, and Salwatty, and on the east the island of Papua or New Guinea, and stopping at the 132d degree of east longitude, at the equator; thus giving to Asia the fertile islands of Sumatra and Java, the great island of Bornéo, Amboyna and the Spice Islands, the Celebes Islands, and to the north of the equator the Philippines, the Pelew Isles, the Carolinas, the Ladrones, the isles of Japan, the Kurile Isles, and, beyond the latitude of 50 degrees, the Aleutian or Fox Islands. The other boundaries of Asia are, on the south the Indian Ocean, and on the south-west the Straits of Babelmandib and the Red Sea, separating it from Africa, with which its only point of junction is by the Isthmus of Suez. Asia is divided from Europe towards the west by the Mediterranean, the Archipelago, the Straits of the Dardanelles and of Constantinople, the Black Sea, the Straits of Caffa, and the Sea of Azof. Here this natural boundary ceases; and from the Straits of Caffa to those of Waigatz in the Northern Ocean different boundaries have

Asia.

been assumed. Some will have the ancient Tanais, now the Don, to be the natural boundary between the two continents of Europe and Asia. But besides that the Don has too winding a course for this purpose, it soon terminates, and we are then left to find our way to the Northern Ocean by an arbitrary line, which has accordingly been sometimes traced as the western limit of Asia from the mouth of the Don to that of the Dwina in the White Sea. But in all cases a natural is to be preferred to an artificial boundary; and the line which leaves the smallest space to be filled up by the fancy of geographers is surely the best. On this ground the Uralian Mountains, which stretch from the 50th degree of north latitude in a northern direction, to the sea of Kara in the Arctic Ocean, constitute a strongly marked boundary between Northern Asia and Europe; and in order to avail ourselves of this boundary, we must approach the Caspian from the Black Sea; and here, therefore, the line of separation between Asia and Europe will run eastward along the rivers Manitch and Kuma, the first flowing by a westerly course into the north-eastern angle of the sea of Azof, and the second eastward into the Caspian. From the mouth of the Kuma the Caspian Sea will mark the frontier of Asia to the mouth of the river Ural, which, along with the Ural Mountains, will complete the western boundary as far as the Straits of Waigatz. From these straits the Frozen Ocean, of which very little is known, bounds the northern shores of Asia to Behring's Straits, which separate the Asiatic from the American continent. From Behring's Straits the Pacific Ocean extends along the eastern shores of Asia to the Straits of Malacca.

Extent.

Asia contains a larger area than any of the other divisions of the globe. Europe is estimated to be 2000 miles in breadth, and nearly 3000 in length; Africa about 4300 miles by 4140; and America about 10,000 miles by the average breadth of 2000. The length of the Asiatic continent, taken obliquely from the Isthmus of Suez to Behring's Straits, is about 7370 miles; and its breadth from north to south, from Cape Comorin in India to Cape Taimura in Siberia, is about 4230 miles. Under the 30th parallel, from Suez to Nanking, its length is less than 6000 miles; from the Straits of the Dardanelles to Cova it is 6000 miles; and under the polar circle it is about 4230 miles. Asia is not of the same irregular form as America, nor is it, like that continent, broken into two natural divisions of North and South. It forms, like Europe and Africa, one continuous mass of solid continent. It is surrounded on all sides except the west by the sea; and, by the provident economy of nature, it has on this side, for half its length, the two great navigable inlets of the Red Sea, which for the space of 1400 miles divides Arabia from Egypt and Abyssinia; and of the Mediterranean, which, penetrating into the land from the west to the depth of nearly 2000 miles, and skirting the whole extent of the European and African shores, gives to Asia a sea-coast of nearly 1500 miles in extent, and secures a navigable communication on this side with the Atlantic Ocean, as well as with Africa and Europe. The northern shores of Asia are occasionally irregular and broken, and indented with some deep inlets, which it is useless to enumerate, as they can never, in those frozen regions, be subservient to the purposes of commerce. On the eastern shore there is the sea of Ochotsk, in breadth between 300 and 400 miles, inclosed on the east by the peninsula of Kamtschatka, projecting southward to a great length, and running out into the Kurile Islands; and on the west by the shores of Siberia, part of Chinese Tartary, and the island of Saghalien. The islands of Japan, which commence where the Kurile Islands terminate, stretch along the shore for above 600 miles, and inclose between them and the coast of Chinese Tartary the Sea of Japan. These islands are succeeded as we advance southward by the Loochoo and other islands, by the large island of Formosa, and finally by the Philippines, Celebes, Borneo, Sumatra, Java, and other groups of the Indian Archipelago. Between the islands of Japan and the coast of Corea, which shoots out southward, is the Strait of Corea, 60 miles in breadth; and between the coast of Corea on the east and the Chinese shore on the other, is inclosed the Yellow Sea, which penetrates northward into the land, and forms a deep inlet, which is of great utility to the commerce and navigation of the northern provinces of China. The southern shore of Asia, from Cambodia to the Red Sea, presents an immense waving line, the ocean and the land alternately encroaching on each other, and forming immense bays and gulfs, and peninsulated tracts of land. Thus, on the eastern extremity, the Gulf of Siam is formed by the kingdom of Cambodia on the one side, and on the other by the peninsula of Malacca, the most southern point of Asia; and westward of this peninsula the Indian Ocean, advancing northward, forms the Bay of Bengal, bounded on the east and west by the two great Indian peninsulas. The same Indian Ocean makes another deep inroad into the land, between Arabia on the west and Hindostan on the east; and towards the north-western frontier of Hindostan it forms the two smaller gulfs of Cutch and of Cambay. On the opposite shore it penetrates deeply into the land, and forms the Persian Gulf, which divides the Persian from the Arabian shore, and is 600 miles in length and 220 miles in its greatest breadth, though at the entrance it is not above 55 miles broad.

Islands.

The islands of Asia on its southern shore are the Andaman Islands, the Mergui Archipelago, and the Nicobar Isles on the eastern side of the Bay of Bengal; and on the opposite coast of Coromandel the large island of Ceylon. The Laccadive and Maldive Islands lie off the coast of Malabar; and in the Persian Gulf is the celebrated island of Ormuz, formerly the seat of a splendid city and of an extensive commerce. In the Mediterranean are the islands of Cyprus and Rhodes, which belong to Asia.

Physical aspect.

The interior structure of this continent is on a scale of peculiar magnificence: its mountains are of stupendous height; and these, together with its great rivers and its vast and boundless plains, impress on the mind the highest conceptions of natural grandeur. America, which vies in some respects with Asia in its imposing aspect, is nevertheless formed on an entirely different plan. It is long in proportion to its breadth; and throughout its whole length, from Cape Pilares in the Straits of Magellan to its northern limits on the Frozen Ocean, runs the vast ridge of the Cordilleras in South America and the Rocky Mountains in North America, which, rising suddenly and abruptly to their height about 200 or 300 miles from the Pacific Ocean, but sloping more gradually towards the Atlantic for the space of 1500 or 2000 miles, give to the country its peculiar form and character. Asia, on the other hand, which is a more solid and compact territory, attains its highest elevation towards the centre of the country; and Central Asia is accordingly a vast platform, of an irregular figure, raised to a great height above the surrounding country, and faced on each side with an immense mountain-wall, formed of enormous rocks and peaks, which tower into the regions of perpetual snow.

Mounta and plai

The high land which these mountains seem to support on all sides reaches in a direction north and south about 1200 miles, namely, from the 30th to the 50th degree of north latitude; and in length about 2000 miles east and west, from the Caspian Sea to the Lake of Baikal on the north, and on the south from the sources of the Indus to those of the Burrampooter. It is the largest tract of elevated ground which is to be found in the globe, and has been

generally distinguished by the appellation of Tartary, being the native country of all those savage tribes which, under the names of Huns, Tartars, Turks, or Mongols, have at different periods desolated the world. It contains generally the extensive country of Thibet, which lies on the northern side of the Himalaya range; Chinese Tartary in the east; and, to the west of the Chinese empire, Independent Tartary, which lies on the northern declivity of the great ridge, and comprehends the countries watered by the Jaxartes and the Oxus, as far west as the Lake Aral and the Caspian Sea; in which are Buckharia, Balk, the cities of Buckharia, Samarcand, Khyvah, &c. and which may be more distinctly pointed out as the country that lies between the frontiers of China on the east, of Persia on the south, and of Russia on the north. The high land of Central Asia constitutes the proper country of Tartary, and is generally of a rude and desolate aspect. It consists of low rocky hills, destitute of vegetation; of extensive arid plains; and occasionally, for the space of 1000 miles, of great deserts of loose sand, which being carried about by the winds, is raised aloft in drifting clouds, as in Arabia and Africa, and adds greatly to the danger of journeying in those inhospitable regions. The cold of winter is piercing and severe, from which the Russian embassy, in their journey to Peking through the deserts of Cobi in 1820, suffered grievously in the month of October, the thermometer being frequently below zero; while in summer the country is often afflicted with long-continued drought, which burns up the pasture, and occasions great mortality among the cattle, the chief subsistence of the pastoral tribes by whom this region is inhabited.[1] But the uniform dreariness of the scene is at times relieved by flowing rivers, and also by luxuriant meadows, on which the inhabitants feed their flocks, shifting their habitations with the seasons, and wandering over the desert in quest of pasture. The ridges of mountains which encompass and uphold the great central plain of Asia gradually subside, though somewhat irregularly, into lower ridges, with intervening and fertile valleys, and finally into the plains, which spread outward, as from a common centre, to the sea. Thus, on the north of the Altai Mountains we have the vast expanse of the Siberian plains, through which the great rivers, the Irtisch, the Yenesei, and the Lena, roll their lazy currents to the Northern Ocean. On the eastern declivity, which is deversified with some lofty ranges of mountains, stretches out the empire of China, with the extensive regions of Chinese Tartary; and the rivers Hoangho and Yang-tse-Kiang here pursue an easterly course to the Pacific, while the great river Amur is turned towards the north by a ridge of mountains that diverges from the great body of high land. On the south the mountainous ridge of the Himalaya descends into the low country of Hindostan and India beyond the Ganges; while the western crest of mountains, falling to a lower level, forms the table-land of Persia and the mountainous countries of Western Asia, until, in the south, it finally subsides into the Arabian mountains and plains.

The southern front of Central Asia overlooks Hindostan and the countries to the east, and consists of the great ridge of the Himalaya or Snowy Mountains, which, commencing near the Burrampooter on the east, run in a direction nearly north-west, as far as the country of Cashmere, forming the magnificent boundary of Bengal on the north. From Cashmere the general direction of the ridge is south-west, as far as the snowy peak of Hindoo Coosh, to the north of Cabul, in long. 69. 12. E. The name of Hindoo Coosh is applied to the whole of this ridge, which declines in its progress westward to a lower level, and is neither so conspicuous among the mountain ridges by which it is surrounded, nor does it any longer present a continued line of perpetual snow. It is crossed by various routes from Candahar northward to Balk, about 50 miles west, where, in the mountain passes, snow is only found for four months in the year. Those mountains, in extending westward to Herat, in long. 62. 15. E., still continue to decline in height, and appear to be lost among the confused masses of the Paropamisan chain.

For a long period Europeans were but imperfectly acquainted with those interesting regions of interior Asia, and the Andes of America were supposed greatly to exceed in height this mountainous barrier of Hindostan. But since the gradual extension of the British conquests in Central India, several enterprising travellers have ascended these mountainous tracts; and it is now ascertained, from the accurate mensurations of Captain Webb and others, that their loftiest summits exceed the height of any other mountains in the world. The height of the Andes has indeed been underrated, as well as that of the Himalaya range. Chimborazo, estimated by Humboldt to rise 21,440 feet above the level of the sea, was formerly supposed to be the most elevated peak of those mountains. But from subsequent observations made by Mr Pentland, it appears that the summit of Illimani is 24,350 feet, that of Sorate 25,400 feet in height,[2] which is still somewhat inferior to the highest summits of the Asiatic chain, 27 different peaks of which were found from Mr Webb's corrected observations to range from an altitude of 17,994 to 25,669 feet in the Hindoo Coosh Mountains, which are a continuation of the Himalaya chain to the west. Lieutenant Macartney, who accompanied the British embassy of Mr Elphinstone into Cabul, found one of the highest peaks to rise 20,493 feet above the level of the sea. The elevated table-land of Central Asia was calculated by Captain Webb to stand generally at a level of 15,000 feet. The lofty summits of these stupendous mountains, towering aloft in all their natural majesty, fill the mind of every traveller with astonishment and awe; and the bright outline of white, when it is projected on the deep azure of a cloudless sky, is seen at the prodigious distance of 150, and, according to some, of 250 miles.

To the south of the main ridges of the Himalaya and Hindoo Coosh the land declines from its height, and presents a lower terrace of mountains, which runs parallel to the great range, and by which, as well as by branches issuing from it, the country is still rendered sufficiently rugged, though there are intervening valleys of great beauty and fertility. In the hilly districts thus formed under the higher mountains are the countries of Assam, Bootan, Nepaul, Kumaon, and Sirenagur. Those lower hills rise with a steep ascent from the plains of Bengal. According to Major Rennell, the southernmost ridge of the Bootan Mountains attains nearly a mile and a half of perpendicular height in a horizontal distance of 15 miles; and, from the summit, the traveller looks back with astonishment on the extensive prospect of the plains beneath him. Where the great range changes to a westerly direction, near the sources of the Indus and the Ganges, the lower mountains are separated from it by a wider interval, which is occupied by the high valley of Cashmere; and to the south and south-west is a mountainous country, which on the north bounds the Punjaub, or the country of the five rivers, namely, the head streams of the Indus, which were crossed by Alexander the Great in his invasion of India. To the south of those well-watered

[1] Timkowski's *Travels of the Russian Mission through Mongolia to China.*

[2] *Edinburgh Review*, No. c. p. 365.

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plains extends a tract of sandy desert almost to the Gulf of Cutch on the Indian Ocean. From the Hindoo Coosh Mountains several extensive ranges, though of inferior height, branch off to the south and west, and spread over the country to the west of the Indus as far as the Indian Ocean and the Persian Gulf. Some of these, such as the Soliman range, are still diversified with snowy peaks, though their height gradually declines as they recede from the central high lands of the country.

At the distance of about 200 miles to the north of the great Himalaya ridge there is another inner range of lofty mountains, which, though it does not rise quite so high as the exterior ridge, runs parallel to it, and is known under the appellation of Mus-tag or Moos Taugh, signifying, in the dialect of the country, Ice-hill. It extends as far as the 67th degree of east longitude; and between it and the main ridge of Himalaya and Hindoo Coosh is inclosed an elevated table-land, extending eastward into Thibet, though it is but little known beyond the meridian of Ladac, in 75. 12. E. The vast deserts of Central Asia are indeed rendered almost inaccessible by the mountain-wall which surrounds them; and hence a comparatively small portion of the country has been explored by European travellers.

The western crest of the great Asiatic high lands is formed by a range of mountains which leaves the chain of Hindoo Coosh in 71° east longitude, in a direction east of north, and is known by the name of Belur Tag, a corruption, according to Elphinstone, of Beloot Taugh, or Cloudy Mountains. This range of mountains, though inferior in height to that of Hindoo Coosh, has generally snow on its summits. It crosses the ridge of Moos Taugh, and is continued towards the north till it reaches the chief range of the Altai Mountains, which form the northern barrier of the great central plains. It is the natural boundary between Chinese and Independent Tartary, and the dividing ridge from which the rivers flow east and west into both countries. Here is also the dividing ridge between the Oxus and the Jaxartes, which flow northward into the lake of Aral, and the great Indus, which takes a southerly course to the Indian ocean.

From this great western boundary of the central plains the country descends slowly to a lower level by successive ridges of rugged and desolate mountains, intermingled with high and desert plains, and fertile spots scattered at great distances over the barren waste. Towards the north these mountainous ridges do not seem to extend beyond the sea of Aral, or about half way between the high land of the interior and the Caspian Sea, leaving on the north-west of the Aral vast plains, the habitation of pastoral tribes; and on the west of the Caspian Sea the desert expanse of Khauresme or Carisme, the abode of predatory hordes, who infest the surrounding countries. To the south of the Caspian extends the great table-land of Persia, which consists of mountainous ridges, varied with elevated and barren plains, which, judging from the extraordinary severity of the winter cold, must be raised from 3000 to 4000 feet above the level of the sea. Persia is situated in this manner on the great western declivity of Asia; and its mountains are connected with those of the great central ridge of Hindoo Coosh, which, extending westward, under the name of the Paropamisan Mountains, to the south of Balk and to the north of Cabul or Afghanistan, sends forth branches which spread over Persia in various directions in the south as well as in the north. The northern ridge, taking a north-westerly course, turns westward to the Caspian Sea, diverging in its progress into various ramifications towards the south. It passes along the southern shore of the Caspian; and for a space of 1500 miles, namely, from the eastern country of Balk to the Persian province of Azerbijan, west of the Caspian, it appears to form the boundary and rampart wall of a great table-land to the south, which extends eastward beyond the Persian territory, and is estimated to be 3000 or 4000 feet higher than the flat country between it and the Caspian Sea on the north, or than the desert which extends eastward of this sea into the country of Balk; and so steep are those mountains, generally known by the name of the Elburz Mountains, on the north, that the low country comes suddenly up to their base as to a wall. This northern chain of mountains appears to unite, in the western provinces of Persia, with another chain issuing from the great western coast of the central plains farther to the south, and to form that mass of mountains which separate Armenia from Mesopotamia, and from which diverge westward into Asia Minor, along the shores of the Mediterranean, the celebrated ridge known to the ancients under the name of Mount Taurus, and northward between the Black Sea and the Caspian the mountain chain of Caucasus, which rises to a great height, being in many parts above the line of perpetual snow. This appears to be the highest continued tract of elevated territory in Western Asia; and it gives rise to the great streams of the Euphrates and the Tigris, which flow southward into the Persian Gulf, as well as those rivers flowing northward into the Euxine; also to the Aras, the ancient Araxes; the Kur and the Kuma, which run east into the Caspian; and to the Kuban, and other inferior streams, which, by a westerly course, reach the Black Sea. This mountainous tract of country has chiefly a southern exposure, and the dividing ridge between the waters which flow south and north being on the borders of the Black Sea, the streams flowing northward from the mountain tract into this sea are consequently insignificant in size compared with the Tigris and the Euphrates, which run down its southern declivity. Towards the east the streams, having to run over a larger space before they reach the Caspian Sea, are of course more considerable.

From this elevated tract of country, which takes a westerly course on leaving the great ridge of the Hindoo Coosh Mountains, its altitude declining as it advances in this direction, various lateral ridges, of inferior height to the main ridge, project towards the south, inclosing between them extensive valleys or low countries. The most westerly of these cross ridges is that which begins from the body of Taurus, near the sources of the Euphrates, at the northern extremity of Syria. This ridge proceeds towards the south, and afterwards inclining to the south-west, it skirts the western shore of the Mediterranean, where it is known under the names of Amman, Sinai, Syria, &c.; and in its course southward it forms the two ridges of Libanus or Lebanon, the mountain of this name being of great height, as is indicated by its snow-clad top, and the inferior ridge of Anti-Libanus to the east. Having passed the Mediterranean and the southern border of Palestine, it advances to the eastern coast of the Red Sea, where it spreads out and forms the central mass of the Arabian mountains, and the ridges which run along the eastern shores of the Red Sea and terminate in Arabia Felix, on the shores of the Indian Ocean.

The northern front of the great central plain of Asia is formed by the vast range of the Altai Mountains, which, under different names, traverse the whole extent of this continent from east to west for a space of not less than 5000 miles. At their western extremity they join the Ural Mountains, which seem to be a continuation of them; and they stretch almost due north in a direction nearly parallel to the course of the Oby, until they reach the shores of the Frozen Ocean, and, crossing the narrow

strait of Waigatz, they terminate amid the rigours of winter in the desolate island of Nova Zembla. On the east the Altai Mountains send forth two ridges, which appear, in the same manner as the Ural ridge, to be a continuation of the original chain, and which reach to the utmost extremities of Asia. One of these, under the name of the Zangai or Changai Mountains, extends in a direction south-east, and, attaining a great height, terminates in the Gulf of Corea, to the northward of Peking. Another chain, namely, the Daouria or Nertschinsk Mountains, proceeds north-eastward along the Gulf or Sea of Ochotsk, and only terminates with the limits of the continent in the vicinity of Behring's Straits. From this chain an inferior one breaks off, and taking a south-easterly direction, penetrates to the southern extremity of the peninsula of Kamtschatka. This northern bulwark of the central high land of Asia is greatly inferior in height to the Himalaya and Hindoo Coosh Mountains, the boundary on the south. Its elevation is not supposed to exceed 5000 or 6000 feet, which is sufficient, however, in that northern latitude, to bring it within the line of perpetual snow. Besides the outward ridge, which faces the north, there are interior and parallel ridges, imperfectly known, and between which the country spreads out into elevated plains. It is in these interior and apparently higher mountains that the head waters are to be found of the Irtisch, the Oby, the Yenesei, and the Lena, which pierce through deep defiles in the outer ridge of the Altai Mountains, and make their way through the plains of Siberia to the Frozen Ocean. The great river Amour, however, being confined by this barrier, and turned aside to the west into Chinese Tartary, finally reaches, by a northerly course, the Sea of Ochotsk. To the north of the Altai Mountains the country subsides into the low country of Siberia, which, with occasional ranges of high ground, presents one vast plain from the base of the Altai Mountains to the Arctic Sea. Here are three tracts, or steppes as they are called, which extend for hundreds of miles on a dead level, and exhibit the same aspect. Of these the steppe of the Issim extends, in the south-western part of Asiatic Russia, along the base of the Altai chain, from the Ural river and the Caspian Sea, across the sources of the Tobol, the Itchim, and the Irtisch. The steppe of the Irtisch reaches from that river to the Yenesei, a space of 1000 miles from east to west; and it seems to be continued between the lower course of the streams as far as the Frozen Ocean. A similar tract reaches from the Yenesei to the Lena. These plains are generally barren: some of them abound in rock-salt and in salt lakes, others are covered with deep forests, and some parts are fitted for agriculture or pasturage. They are of the most dreary aspect; and as they advance into the northern latitudes, they combine the double evil of a barren soil and a severe climate.

Of the mountains inclosing the great plain of Central Asia on the east, and which subside into the lower country of China, we cannot attempt any geographical description, as they are very imperfectly known. From the nature of the country, however, which is known, and from the direction of its mountains and streams, we may deduce some general inferences as to those regions which are unknown. The great chain of the Himalaya Mountains, on entering the peninsula beyond the Ganges, inclines towards the south; and numerous chains of inferior magnitude breaking off in this direction, divide that peninsula into long parallel valleys, in which the great streams of the Irrawaddy, the Menam, the Maygue, and the Japanese, flow southward to the Indian Ocean. Those mountains which thus break off from the Himalaya range to the south also diverge, without doubt, towards the north; and they will thus form the western frontier of China, and the mountain wall which supports the central table-land on the east. We are ignorant of the height or other particulars regarding this chain. But from the direction of the two great rivers, the Hoangho or Yellow River, and the Yang-tse-Kiang or Blue River, which water the central regions of China, and which have their sources in the interior deserts, it is evident that from the central high lands the country must be a continued declivity, varied occasionally with lower terraces of hills, to the Eastern Ocean. A range of mountains runs through the southern provinces of China, which seems to be a prolongation, on a lower scale, of the great Himalaya ridge; and a lofty chain of naked rocks, already noticed, runs along the southern frontier, and separates China from Tartary. It is a branch of those mountains which turn aside the river Hoangho into a northerly direction; and it is only by a circuitous and winding turn that it regains its original course towards the east.

Rivers.

The rivers of Asia correspond in grandeur with all the other great natural features of the country. A river, it is evident, will be great or small according to the extent of the basin or valley of which it is the natural drain, and according also as it recedes from or approaches the regions of rain which lie under the equator. The largest rivers are accordingly those which have the longest course, and that course within the tropics or near to the equator; and all the great rivers of the globe will be found to coincide with this hypothesis; many of those in high latitudes with a long course being inferior in magnitude to the rivers within the tropics which have a shorter course, and which are fed by the periodical rains. The Amazons is unquestionably the largest river in the world. It pours into the ocean a stream of the greatest magnitude, being 180 miles broad at its mouth, and of an amazing depth; and it combines the two necessary conditions of a great river. It has a long course of fully 3000 miles (chiefly within the 6th or 7th degree of S. lat., where it crosses nearly the whole breadth of America), swollen into a most prodigious volume of water by the almost constant rains of the equator. The Mississippi in North America has a long course, including its windings, of nearly 3000 miles; and it is the only drain of that vast valley situated between the Rocky Mountains on the west and the Allegany Mountains on the east, the area of which cannot be less than 2,000,000 of square miles. But its course lies without the limits of the tropical rains; and it wants, consequently, one of the requisites of a great river. It will be found, accordingly, that it does not pour into the ocean such a volume of water as the Orinoco, the course of which is not estimated to exceed 1300 or 1400 miles; and its basin is inferior in extent by two thirds to that of the Mississippi. Yet this latter, though a magnificent stream, is not, opposite New Orleans, 102 miles from its mouth, above 132 feet deep during the inundation, and 4500 feet broad; while the Orinoco was found in the dry season at St Thomas, 250 miles from its mouth, to be 390 feet deep and 2300 feet broad.[1] In Africa, again, the Nile has a course of above 2000 miles, and it has its rise within the tropics. But its northerly course carries it away from the periodical rains into Northern Africa, where rain seldom or never

[1] Depons, *Voyage a la Partie Orientale de la Terre Ferme dans l'Amerique Meridionale*, 1801–2–3–4. The rise of the river during the rainy season is stated by the same author to be 13 fathoms opposite St Thomas. Tome iii. p. 301.

falls; and hence, for the space of 1000 miles, it receives not the aid of a single tributary stream. It is merely the collected rains of the northern tropic, diminished rather than increased as they flow through the African deserts to the Mediterranean. Hence the magitude of the Nile is not in proportion to the space over which it flows. It has not so large a stream as either the Orinoco or the Ganges, which, though they have each a shorter course, are yet swollen to a greater size by the tropical rains. If the Nile had flowed in an opposite direction towards the equator, it would have ranked in the first class of rivers. The vast expanse of Asia presents an ample area for the formation of the largest streams. In the interval which extends from the loftiest ridges of the central mountains, the multitudinous waters of the most distant regions may be poured into one common channel; and the rivers of Asia, therefore, from the space over which they flow, ought to be the greatest in the world. This, however, is not the case. They are indeed most magnificent streams, and present, in the roar and foam of their impatient waters while they are yet imprisoned within the mountains, in the violence with which their conflicting tides successively intermingle in their progress to the sea, and in the breadth and majesty of the overflowing stream sweeping over the plains, all the most imposing phenomena of the greatest rivers. But they are inferior in magnitude to the chief rivers of South America—to the Orinoco, and still more to the Amazons; and the explanation of this fact must be sought for in the position of Asia, of which only the southern extremity is within the region of the tropical rains. The solid mass of the Asiatic continent just reaches the northern tropic; and it is only the peninsular tracks of Arabia, Hindostan, and the narrow strip of Malacca, that shoot out beyond this boundary towards the equator. The greatest rivers of Asia, namely, the Ganges and the Indus, are consequently without the limits of the tropics. But in Asia the rainy season has a wider range than in Africa, where it does not extend beyond the northern tropic. In the tropical countries of Asia this season sets in with the south-west monsoon, which drives the gathering clouds from the Indian Ocean over the plains of Hindostan, and as far as the northern barrier of the Himalaya Mountains, by which their progress is at length arrested, and extends the periodical rains over the whole intervening country. Hence both the Ganges and the Indus are fed by these rains, though the northern latitude in which they flow would in Africa place them in the driest regions of the earth. They accordingly rank among the rivers of the first class, whether we look to their length of course or to the body of water which they pour into the ocean. They both have their rise in the great Himalaya ridge, among the regions of perpetual snow, at no great distance from each other, when they diverge—the Indus into a south-westerly, and the Ganges into a north-easterly course, according to the slope of the land, and reach the Indian Ocean exactly on opposite points of the peninsula of Hindostan. They form each the great drain of their respective valleys, and they have many tributaries, which it is unnecessary here to state in detail. The great river of the Brahmaputra, which is fully equal to the Ganges, has its source from the opposite side of the same mountains; and after a long easterly course among desert mountains, in which it approaches the confines of China, it winds towards the west by a vast circuit round the mountains, and joins the Ganges after a course of about 1600 miles. The other great rivers of Eastern Asia which flow down the southern declivity of the central mountains are, the Irrawaddy, which has its rise in the eastern mountains of Thibet, and, after a course of 1200 miles, falls by many mouths into the Gulf of Bengal; the Menam, which falls into the Gulf of Siam; and the Camboja, which, rising in the northern mountains, after a course of nearly 2000 miles falls into the Chinese Sea to the east of the Gulf of Siam, in about lat. 10. S. The course of all these rivers lies more within the region of the rains than that of either the Indus or the Ganges; and the Irrawaddy, and especially the Camboja, are of great length. But the basins or valleys of which they are the outlets are long and narrow, and their collected waters are not sufficient for the formation of such large rivers as the Indus or the Ganges. Yet the Irrawaddy is of great magnitude; it has its delta and its periodical overflow; and during the rainy season it is a mile broad, and of great depth. It decreases during the dry season to half a mile in breadth and to a depth of eight feet. The Menam is not a river of any imposing magnitude; and of the Camboja we have but very imperfect accounts; but judging from the great length of its course, which is also within the region of the heaviest rains, its stream can hardly be inferior to the largest rivers of Asia. It is said to be navigable for large vessels 40 leagues from its mouth, to be in general two miles wide, and so deep that ships can approach almost close to its banks. The peninsula of Hindostan, which projects southward, and is subject to periodical deluges of rain, is not of sufficient space for the formation of any great river. Amid the lower ranges of mountains, the Nerbuddah, which in some countries would be thought a large river, takes its rise, and flows from east to west down the western slope of the great plain of Central India into the Gulf of Cambay; and here commences the mountain range of the Ghauts, which runs along the coast of Malabar to Cape Comorin, at the distance of not more than 100 miles; while from the opposite coast the intervening country extends from 300 to 700 miles; thus exhibiting on a small scale the formation of the American continent, which rises to its height at the distance of about 300 miles from the Pacific Ocean, leaving the vast space on the other side of the mountains to the Atlantic for the course of all the great rivers. In like manner, all the great rivers of Hindostan flow down the eastern declivity of the Ghaut Mountains, namely, the Mahanuddy, the Godavery, the Kistnah, the Tuptee, and the Cavery, which flow from the Ghauts in an easterly direction across the country to the Indian Ocean. The streams on the opposite declivity of the mountains have necessarily a short course, and are chiefly inconsiderable mountain torrents, except when they are swollen by the rains. The Euphrates and the Tigris, which have their origin in the mountains of Armenia, are the only other considerable rivers of Asia which flow southward into the ocean. They are not rivers of the first class, not nearly equalling either the Ganges or the Indus, though the Euphrates must be nearly equal to the Danube, the greatest river in Europe; and they are in no respect tropical rivers, as they derive their supplies from the melting of the snows, and from the spring and the winter rains. It is accordingly in January that the great overflow of the Euphrates takes place. It may be here remarked, that throughout Asia the countries without the limits of the monsoon depend on the rains, which generally fall in the spring, and more copiously in the winter, though these rains are far from being so regular as the rainy season within the tropics.

The great ridges of the Himalaya and Hindoo Coosh Mountains divide the rivers of Asia which flow southward to the Indian Ocean, from those which flow northward or eastward into the central deserts of Tartary. They do not appear, however, to be considerable; and are probably lost amid the wastes of sand extending over a great portion of that country, or in some of its interior lakes. On the north

the Oxus, a great river, and the Jaxartes, of which the sources approach those of the Indus and the Ganges, being on the opposite sides of the same high land, emerge from the mountain deserts into the plains, and, after a long course, both reach the interior lake of Aral, to the east of the Caspian Sea. The great rivers in the east of Asia, namely, the Yang-tse-Kiang and the Hoangho, which rise in the unknown deserts of Thibet, and flow through China into the Eastern Seas, have each a course of extraordinary length; and they must no doubt pour a large stream into the ocean. But we have no accurate accounts of their size, neither of their breadth nor depth; and as they are not within the limits of the rains, the magnitude of their stream cannot be in proportion to its great length, as the rains of these northern regions never accumulate into such a body of water as the rains of the tropics. The great river Amour, which runs down the eastern declivity of the Asiatic high lands, is remarkable for the length of its course; but though it must be a great river, we have no accurate information respecting it.

On the north, where the central table-land of Asia declines towards the Frozen Ocean, there is ample space for the formation of rivers; and accordingly, through the vast and desolate wastes of Siberia flow the Irtisch, the Obi, the Yenesei, and the Lena, by a winding course, to the Arctic Sea. The whole breadth of Asia, from the Eastern Ocean to the Ural Mountains, is drained of its waters by these four rivers and their tributaries; and the Irtisch, the Yenesei, and the Lena, from their source in the unknown deserts of Chinese Tartary, must flow over a space of nearly 4000 miles, which greatly exceeds the course of the great Amazons. We know little as to the volume of water contained in these rivers, which, though it must be great, yet, judging from the magnitude of other rivers in the same latitude, cannot equal that of the great tropical rivers. The Volga is a large river; it has a great length of course; but its depth does not exceed 15 feet.[1] The basins of the northern rivers of Siberia are no doubt of great extent; but even though we estimate their streams at double the magnitude of the Volga, they will only attain a depth of 30 feet, which is not one tenth part the depth of the Orinoco, though, according to Major Rennel, it is equal to that of the Ganges.

Lakes.

Asia is distinguished by the variety and extent of its interior lakes; and its extensive table-lands, intersected by mountains, favour the collection of those masses of water. In general these lakes are distinguished by the saline, brackish, or sulphureous nature of their waters. Asia Minor contains numerous salt lakes which have no outlet, and some of them of considerable extent. To the west of the Caspian Sea are the lakes of Van and Urmia, Ooroomea or Shahee, the waters of which are intensely salt.[2] In Syria, the great chains of Libanus and Anti-Libanus contain several lakes, the most celebrated of which is the Lake Asphaltites or the Dead Sea in Palestine, whose bituminous waters cover a space of nearly 500 square miles. The Caspian Sea on the western declivity of the central heights is beyond all comparison the largest lake that is known, being in length 646 miles from north to south, and 265 in extreme breadth; while the greatest length of Lake Superior in North America is not more than 381 miles in length and 161 in breadth. Lake Aral, to the west of the Caspian Sea, is 150 miles in length by 60 in breadth; and to the east the lakes of Aksakol, Telegul, Balkashi or Palcati, and numerous smaller lakes, are scattered over the region which lies between the central mountains and the Caspian Sea. In all these lakes the waters are salt or brackish. Persia contains in its salt deserts numerous small lakes; and also the large lake of Zere or Zurrah, which covers a space of 1000 square miles.

Asia.

On the northern declivity of the table-land of Tartary are scattered numerous lakes, many of which are scarcely known by name in Europe, though they are of great extent, and are fed by the rivers from the surrounding mountains. Of these the Lake Tchany or Czany is the largest. The high plains in the table-land of Tartary and Thibet, environed on all sides by lofty mountains, are the receptacles of the imprisoned waters of these elevated regions. Near the southern ridge of this mountain tract is found the large and variously designated lake which gives rise to the Irtisch; and the southern plains, inclosed by the mountains of Chinese Tartary and Thibet, the most elevated summits of Asia, are said to contain considerable rivers, which are either lost in the sands or in interior lakes. The country of Thibet abounds in lakes, in most of which the waters are salt. Some of these are of great extent. The Terkiri, according to the accounts of the Chinese missionaries, from whom we derive our chief knowledge of these vast countries, is 60 miles long by 40 broad. The Kokonor, which signifies a great sea, is on the borders of China: it contains 1840 square miles, and a space of 600 miles on both sides of Lake Terkiri, and includes no less than 23 lakes, some of them of considerable extent. There are comparatively few lakes in the exterior plains of Asia.[3] The Lake Baikal, in Upper Siberia, is 366 miles in length by from 20 to 53 in breadth. But Lower Siberia is one continued series of marshes, with intervening plains adapted for pasture. China contains few lakes, the country being one continued declivity; and from the same cause the peninsula of Hindostan contains not a single lake of any extent.

Structure of Asia not favourable for maritime intercourse.

From its internal structure Asia does not possess the same advantages of navigable intercourse as the other divisions of the globe. From the peculiar structure of the American continent, all the great rivers flow to the east or to the south-east, some of them across almost the whole breadth of the continent, and scarcely leave any part far out of the reach of a navigable communication. North as well as South America has also a southern or eastern exposure, in consequence of which the Mississippi, the Orinoco, the Amazons, and the Plata rivers, flow either to the south or to the east, into the seats of civilization and of commerce. The structure of Asia is different: it is of the most imposing grandeur and simplicity, and is eminently calculated to impress on the mind an idea of vastness and of majesty; but it is not so well adapted for the purposes of internal improvement. From its form, which rises into a great table-land towards the centre, the rivers naturally descend on all sides to the sea, as radii from a common centre, leaving vast tracts and high plains a prey to perpetual drought and sterility, and without any navigable communication with the sea. Not that the great table-land of Asia, if we except the vast sandy deserts of Cobi and Shamo, presents such a uniform aspect of frightful wastes as is generally supposed. It is not by any means wholly destitute of water and vegetation, but contains extensive plains fertilized by rivers flowing into interior lakes, and well adapted for pasturage, the chief occupation of the inhabitants, and which, if they were properly cultivated, would yield grain and other produce. But the want of moisture is still the chief disadvantage; and the streams which arise in this elevated region having no outlet to the sea, afford no facilities of

[1] Pallas' *Travels*.

[2] Fraser's *Travels in the Persian Provinces on the Southern Banks of the Caspian Sea*.

[3] *Histoire Général des Voyages*, tome vii. p. 108.

Asia.

exterior intercourse. This disadvantage necessarily belongs to a country of elevated plains of immense extent, fenced round with mountains, and thus insulated from and almost unknown to the whole world besides. A lake which does not communicate with the sea merely facilitates the communications between its own shores. Hence it is of no material use in the intercourse of a country; and the nature of the ground to which these lakes owe their formation is a positive disadvantage, as its effect is to intercept the interior waters in their progress to the sea, and to collect them into a large reservoir in the heart of the country. Thus the Oxus and the Jaxartes flow into the Aral; and the Caspian Sea, which presents no facilities for internal improvement, is the recipient of some very great rivers. But if they had reached the Black Sea, how much more would they have conduced to the improvement of the country. The great rivers of what we may call Southern Asia, namely, the Euphrates, the Tigris, the Indus, the Ganges, and the streams which run into the Indian Ocean in the peninsula beyond the Ganges, are well adapted for navigation and commerce; and the Ganges more especially is of vast advantage both in fertilizing the soil and improving the intercourse of the country through which it flows. The course of the other great rivers, such as the Indus, &c. would equally promote the same great objects; but the adjacent countries are inhabited by barbarous tribes, who neglect all those natural advantages. The Chinese rivers which wind across that country from the western mountains are rendered eminently subservient to navigation and commerce by that industrious people. But the course of the great rivers flowing from the central mountains into the Frozen Ocean, into which course they are turned by the northern exposure of Asia, is eminently unfavourable for the improvement of the country, as they are carried entirely out of the seats of commerce and wealth to the Arctic Sea, the gloomy abode of perpetual winter. These great rivers, therefore, the Irtisch, the Obi, the Yenesei, and the Lena, owing to their having a northern course, must for ever remain useless to commerce and navigation. They lead to countries from which no benefit can ever be derived, to seas bound up in perpetual ice, and to regions of sterility and cold, which mankind desire to fly from rather than to visit. These rivers, great and navigable though they be, present no outlet to the produce of the interior; nor can they greatly aid the general routes of the traveller in crossing Siberia. They afford considerable advantages, however, especially in their upper streams, for carrying goods into and from China. It is singular that to the west of the Ural Mountains the country should have a southern exposure, and the great rivers of northern Europe, accordingly, the Volga, the Don, and the Dnieper, flow with a southerly course into the Caspian or the Black Sea.

Great natural divisions.

From the general view which has been given of the form and interior structure of this great continent, and of the system of its mountains and rivers, it may be distinguished with advantage into five great natural divisions, namely, Central Asia, Southern and Northern Asia, and Eastern and Western Asia.

1. Central Asia, or the great high lands, with their elevated plains and almost boundless wastes, is, in the eastern parts, chiefly within the limits of the Chinese dominions. It contains Thibet and Chinese Tartary, to whose powers we cannot assign any definite limits. But it is certain that in the south the dominion of China extends very far west, to the 80th degree at least, as it now borders with the British frontier in Hindostan, where Chinese horsemen are placed to guard, with their usual jealous policy, the celestial empire from intrusion. On the north the territories of China border with those of Russia, and the whole intervening tract must be included under the Chinese dominion. But we know little of these wild and desolate regions; and it is uncertain how far the pastoral or predatory hordes which range over them are controlled by the Chinese authorities. The country of Thibet is also bounded by China on the east and on the north, though we cannot exactly determine the limits of their respective territories. Farther to the north the sway of China extends to the 78th degree of E. long., and includes the rich and populous Mahometan towns of Kashgar, in long. 76. 5. 45. E. lat. 39. 25. N., and Yarkund, in long. 78. 27. 45. E. lat. 38. 19. N.; the first reckoned to contain 80,000 inhabitants. It does not seem to be separated from Independent Tartary by any distinct boundary. The countries near the sources of the Indus and the Oxus, about the 78th degree of E. long., are inhabited by wild and independent tribes, who, like most of their race, subsist by pasturage or plunder. Here is Balk, the ancient Bactria or Bactriana, where there are several chiefs who rule over their rude and intractable subjects with a precarious sway. Here is also the city of Buckharia, which, with the surrounding country, is ruled by an independent sovereign; and the independent states of Khyvah and Kokaun, the first extending on and near the banks of the Oxus, between 100 and 200 miles, and the latter divided into two parts by the Jaxartes, and reckoned to be more than 200 miles in length and 150 in breadth. To the west, as far as the Caspian Sea, is the proper region of Independent Tartary, bounded on all sides by the Russian, Chinese, and Persian empires.

2. Southern Asia includes Hindostan from the Himalaya Mountains; on the west Afghanistan and the independent tribes scattered in the lower valley of the Indus; the kingdom of Nepaul on the east; the hilly country of Bootan, the Burman empire, the peninsula of Malacca, and the kingdom of Camboja.

3. Western Asia contains Persia, the peninsula of Arabia, the extensive countries over which Turkey maintains a loose and uncertain authority, comprehending Mesopotamia, Armenia, Syria, and Palestine; Asia Minor, surrounded on the north, south, and west, by the Mediterranean and the Black Seas, and the mountain regions of Caucasus between the Black and the Caspian Seas.

4. Eastern Asia is occupied by the Chinese empire and by Chinese Tartary.

5. Northern Asia forms the Asiatic part of the Russian empire, which extends from the Altai Mountains to the Frozen Ocean.

Climate.

Asia, extending from the equator to the Arctic Sea, necessarily possesses great variety of climate. But though here, as in every other country, the climate is regulated by the distance from the equator, this general law is modified by accidental causes, which it is curious to trace. In the wide extent of Asia great peculiarities of temperature occur, which cannot be very clearly explained. The system of the universe is conducted on so vast a scale that our faculties of observation do not keep pace with its great movements. How can we, for example, trace the rapid course of the winds, on which the temperature of countries so essentially depends, traversing as they do the whole space of the habitable globe at the rate of 1000 miles in 24 hours? How can we ascertain their origin and follow their progress, which is modified by the various interruptions of mountains, continents, and seas? How can we distinctly point out, amid such a complication of unknown facts, the connection between cause and effect? To such inquiries some uncertainty will always attach, and anomalies may appear of which we can offer no solution. In these circumstances, facts are our only

sure guides; and to these, therefore, in the following observations, we shall endeavour to adhere.

The height of the land above the level of the sea is as sure a cause of cold as distance from the equator; and countries are not only cold in proportion to their height, but a mass of cold air is accumulated above them, which, being dispersed, is carried towards the equator, and extends the dominion of cold into the regions of heat. Land and water, also, are the causes either of heat or cold, according to their situation. The great mass of the ocean is little affected by the changes of the seasons; and it consequently preserves the medium temperature of the whole year. Hence the vicinity of the ocean cools the temperature of the equinoctial regions; and in higher latitudes it moderates the extremes both of heat and cold, being in winter of a higher temperature, and in summer of a lower temperature, than the superincumbent air. The surface of the earth, again, imbibes heat or cold much more readily than the ocean; and it is only at considerable depths that it is found to give the medium temperature of the year. The vicinity of land, therefore, in the polar countries, is the cause of cold, while in the southern regions of the equator it is an equally powerful cause of heat. Thus Africa, which extends so far to the south, and which contains a greater proportion of land within the tropics than any other division of the globe, is a vast store-house of heat, from which it is dispersed far and wide, and even reaches the shores of Europe in hot and parching winds; while, on the other hand, the breadth and extent of the American continent towards the north sufficiently accounts for the coldness of its climate, the north-west winds which sweep across its frozen wastes extending their inroads into the regions of heat as far sometimes as Mexico or Vera Cruz.[1] The influence of the ocean in moderating the severity of the winter is exemplified in the climate of Great Britain, where no such intense cold ever prevails as in corresponding latitudes on the continent of Europe, and more especially on that of Asia. The climate of a country is also affected by the direction of the winds; and hence the eastern shores of America, owing to the trade-winds, which blow from the east, and are cooled in their passage across the Atlantic, have not the same sultry heats as the opposite shores of Africa, where the same winds are heated to an intense degree in their passage over the burning deserts of the interior. The northern frontiers of Asia, and its prodigious elevation towards the centre, necessarily consign the greatest portion of it to the dominion of cold. Among the central mountains perpetual winter reigns; and from these snowy deserts the influence of cold is widely extended over the high plains of the interior. In Thibet, which is about the same latitude as Northern Africa or Arabia, namely, between the 30th and 35th degrees, there is a continuous and severe winter of three months, which is of such uniform severity that at its commencement the inhabitants kill their meat, and it is kept perfectly fresh for three months.[2] To the west, along the whole range of elevated land that extends into Persia and to the Caspian Sea, the climate is modified by the elevation of the ground. In the countries of Balk and Buckharia, which lie on the northern declivity of the great ridge of the Hindoo Coosh Mountains, in the same latitude as the south of Europe, namely, the 39th and 40th degrees, and all along the banks of the Oxus, the climate is remarkably severe. For three months the winter is intensely cold, the wind being dry and piercing, and the snow lying deep on the ground. The rivers are all frozen over, and the Oxus during all that period is passable for caravans.[3] The summer, again, is equally hot. Persia, in like manner, being nearly in the same latitude as Arabia, the hottest part of the earth, and having an excessively hot summer, has in the northern and central parts the severe winter of a northern climate, with drifting snow, which lies deep on the ground for three months; and this is owing entirely to its elevation, which is estimated by Fraser to be 4000 feet above the Caspian Sea.[4] The lower valleys and exterior plains of Asia, which lie to the south of the Himalaya Mountains, including Arabia, the southern and flat parts of Persia, Hindostan, and India beyond the Ganges, constitute the tropical and warm regions of this continent, of which the climate, though it agrees in general with their position on the globe, still varies from local causes. Hindostan, for example, and India beyond the Ganges, though they approach nearer to the equator, are not nearly so hot as Arabia or the adjacent countries. The course of the seasons is also more constant; and it is here that we meet with those remarkable winds, the monsoons, which blow six months in opposite directions, from the south-west and north-east, with some slight variations, and which extend their influence over all the countries which lie between the mouth of the Indus and the Chinese Sea. The monsoons follow the course of the sun, and this fact points to the cause of the phenomenon. Heat and cold being the great agents which, by rarefying or condensing the air, disturb its equilibrium, and set the winds in motion, land, when it is heated by the solar rays, acts on the superincumbent air, and causes it to ascend, when it is immediately replaced by an irruption of cold air from the sea. Hence the regular sea-breeze which prevails in all the tropical islands during the day, and the opposite current from the land during the night; and this alternation of the sea and the land breezes, occasioned within 24 hours by the varying temperature of an island, is just an example of the effect that must be produced by a heated continent and by the change of the seasons. As the sun advances into the northern tropic, the land of Asia, Europe, and almost the whole of Africa, is heated by his influence; by which the air being rarefied, and rising aloft, a current of colder air rushes in from the sea. Accordingly it is found, that with the approach of summer, the plains of Hindostan, Burmah, and China, heated by the intense rays of a vertical sun, violently attract the cold air, which flows with a steady stream from the Southern Ocean, exactly in the tract of the heated continent, namely, from the south-west to the north-east. When the sun passes into the southern hemisphere, the monsoon alters its course. Winter now reigns in the mountainous and northern parts of Asia, and the heat in the lower regions is not so great. The land, in place of heating, cools the air, which flows into the warm regions of the south from the north-east in the direction of the continent, as it formerly flowed towards the north from the

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[1] See Humboldt's *Political Essay on the Kingdom of New Spain*. He mentions, that at Vera Cruz the centigrade thermometer sometimes falls, owing to those northern blasts, to 0 or to 32 degrees of Fahrenheit; and that even at Mexico they sometimes, though rarely, bring down the thermometer to the freezing point.

[2] Turner's *Embassy to Thibet*, p. 217, 301, 356.

[3] Fraser's *Narrative of a Journey into Khorassan*, Appendix, p. 95.

[4] Kinneir's *Geographical Memoir of the Persian Empire*, p. 122. It is mentioned in the Journal of a Mr Campbell, quoted by Sir J. Malcolm, that while he was at Tabreez a heavy fall of snow occurred in May; and in December and January the thermometer at night was never above zero. (Sir J. Malcolm's *History of Persia*, vol. ii. p. 509.)

Asia.

south-east. The south-west monsoon sets in about the beginning of June in all the islands of the Indian Ocean, and traverses the southern plains, until it is turned towards the west by the central mountains, and finally arrested in its progress. It is ushered in with the most tremendous thunder and lightning, with tempests of wind and floods of rain. This is the commencement of the periodical rains through all the tropical regions of Asia, which are at their height in July, and gradually abate about the end of September, departing amid thunders and tempests, as they came. Before the setting in of the monsoons there is a clear sky, with a hot parching wind, succeeded by sultry calms, under which all nature seems to droop. The rains effect a sudden and total change in the aspect of the country: the rivers are swollen, the air is pure and refreshing, the sky varied with clouds, and the earth covered with the most luxuriant verdure.[1] Such is the climate of Southern Asia, from China to the coast of Africa. But the peninsula of Arabia is not subject to the influence of the monsoons; and in place of the tropical rains, it has generally, in the mountainous parts, the winter and the spring rains.[2] The climate during summer is hotter than in any other part of the world, the thermometer frequently rising to 110°, and even it is said to 120°, in the coolest and shadiest parts, while dead calms prevail often without interruption for 50 or 60 days, and are succeeded, as the temperature begins to vary and the winds to resume their activity, by violent and hot blasts from the desert. The vicinity of Arabia to the African continent, by which it is sheltered from the cool breezes of the sea, while it receives the sultry air from its burning plains, is unquestionably the cause of its extraordinary heat; and it will be remarked that those violent heats extend eastward from Arabia exactly in the direction in which they are received into the lower valley of the Euphrates and the Tigris, where at Bagdad they raise the thermometer to 120° in the shade. It has been already mentioned that the progress of the monsoons to the north is arrested by the central mountains; and the elevated tract of country, therefore, which lies to the north of this barrier, namely, the kingdom of Kokaun, over which are spread the headwaters of the Oxus, Balk, the ancient Bactriana, Buckharia, and the countries west of the Indus, as far as the Hellespont, depend on the spring and the winter rains which they receive from the west.[3]

Western Asia has been long celebrated for the mildness and serenity of its climate, which is hot and dry, though it is tempered by the cool breezes from the mountain tracts by which it is intersected. In the northern parts, along the coasts of the Black Sea, the country is liable to excessive rains; while the southern shores of the Mediterranean are exposed to the sultry simoom blasts from the African or Arabian deserts.

Northern Asia, of which the Altai chain is the boundary, is the proper region of cold; and the severity of the climate is said to be aggravated by the vast expanse of the continent in the frozen latitudes of the north. In the interior of Asia the milder element of the ocean can have no influence on the rigour of perpetual winter; and from the Arctic Ocean to the Altai Mountains the north wind sweeps without interruption along the Siberian plains, and occasions an intensity of cold which is not experienced in the corresponding latitudes of Europe. It is remarked by Malte-Brun, that the cold increases as we proceed eastward, to such a degree, that on the coasts of Tartary, in the same latitude as France, the winter commences in September. This intensity of cold he ascribes to several causes: 1*st*, To vast mountains covered with glaciers, which rise between Corea and the countries on the river Amour; 2*dly*, to the still greater mass of mountains which separates the Amour from the Lena; 3*dly*, to the thick and cold fogs which constantly overhang those frozen countries, and intercept the rays of the sun; and, 4*thly*, to the absolute want of inhabitants, and consequently of cultivation. There is no doubt that such causes tend to the increase of cold. They must, however, be somewhat counterbalanced by the vicinity of the Eastern Ocean tempering the severity of a Siberian winter; and the greatest degree of cold should still, therefore, be found towards the centre of the continent. On the northern shores of Asia the severity of the cold will not, as in milder climates, be counteracted by the influence of the ocean, which is either covered with solid or with floating ice. The natural coldness of the air in these countries will be aggravated rather than softened by the vicinity of these frozen seas.

Vegetable productions.

Asia, from its vast extent and unequal surface, not only comprehends within its bounds the vegetable produce of the whole earth, from the low creeping lichen which flourishes on the borders of perpetual snow, to all the splendid varieties of tropical vegetation; but it presents these varieties within a very short compass. It would be inconsistent with the plan of the present article to describe in detail the animal and vegetable kingdoms of Asia. It may be therefore generally stated, that the great staples of agriculture, the alimentary plants on which man depends for his subsistence, are, in the tropical countries of Asia, rice, of which there are 27 varieties; maize, millet, and many varieties of a coarser grain called dourra; as well as other species of legumes not known in Europe. The cultivation of these nutritious grains is confined to the plains of Hindostan and the hot countries to the east. Rice or maize may be sometimes seen in Persia, or in the hot plains of Lower Syria; but agriculture in these countries generally depends on the grain of a colder climate. Persia is accordingly famed for the most excellent wheat, which is the chief food, and for barley and millet. Oats are more rarely attempted in that climate. Throughout Syria and Asia Minor, as well as Arabia, wheat, rye, barley, beans, and other grains, are chiefly sown; and in Buckharia, and generally in all the countries that lie between the Oxus and the Caspian Sea, these and other grains, with a variety of leguminous plants, constitute the chief dependence of the inhabitants.[4] Between the 50th and 55th degrees, these grains may with care be raised all over Asia; but beyond this they cannot so well resist the severity of the climate. This is therefore the proper region of barley and oats, the cultivation of which may be extended to the 60th degree. Beyond this the powers of vegetation fail under the benumbing influence of cold; and the earth yields nothing but dwarf trees, lichens, and some species of the wild berry. In ascending the Asiatic mountains, the same varieties of vegetable produce are observed as in receding from the equator, until, at the line of perpetual congelation, all traces of vegetation disappear. But the decrease of heat in proportion to the altitude varies in different situations, according as it is affected by local and accidental causes; and though the most accurate calculations have been made on the subject by Leslie, Humboldt, and others, they are modified by local causes. Thus the limits of perpetual congelation have been fixed by Humboldt at

[1] Elphinstone's *Account of Cabul*, chap. v.
[2] Niebuhr, vol. ii. sect. 29.
[3] Fraser's *Narrative of a Journey into Khorassan*, Appendix, p. 95.
[4] *Ibid*, Appendix, p. 96.

15,700 feet under the equator, and 15,000 in the latitude of 20 degrees; yet Captain Webb, in his journeys among the Himalaya Mountains, observed, on the banks of the Sutledge river, which must have been at least in the 30th degree of north latitude, the finest pastures, and crops of a species of barley from which the natives make their bread, at a height of 15,000 feet, the supposed line of perpetual frost. And at a pass among these mountains, in 30 degrees of north latitude, plants were found that ripened their seed at the enormous height of 17,000 feet. In latitude 30° 25′ the same traveller saw fields at the height of 11,790 feet, not only without snow, but covered with extensive fields of buck-wheat and Tartaric barley. The decrease of heat in proportion to the altitude attained appears not to be subject to any certain rule; and it would be extremely interesting to ascertain by actual observation the height at which the produce of the colder climates could be cultivated in different parts. We cannot fix either the lower or the higher limit at which wheat and other European grains could be brought to maturity among the Asiatic mountains. It is evident that the decrease of heat as we rise above the level of the sea is modified by local causes, in the same manner as when we recede from the equator; and hence the same vegetable produce is not uniformly found at the same height, any more than within the same latitudes. It is possible that in the interior mass of the mountains the cold may be greater than among the exterior ridges, and that the European grain, and the other congenial produce of a cold climate, may not on this account ripen at so high an elevation. It is mentioned by Turner, that he saw wheat in Thibet in a green state, which he was assured would never ripen owing to the severity of the climate.

Of the other plants which minister to the comfort of man, and afford valuable articles of commerce, Asia possesses great variety. The tea plant, which is exported so largely to Europe, is indigenous to China, to which its cultivation has hitherto been confined, and to which it is a source of prodigious wealth. Arabia is the native country of coffee, where it still arrives at its greatest perfection. The sugar-cane is cultivated in Hindostan, though not with the same energy and skill as in the West Indies; and also in some of the hottest parts of Asia Minor, but not to any extent. Tobacco is very generally produced in Southern and Western Asia; and the poppy plant, the great intoxicating drug of the East, is a great article of cultivation in Hindostan, and is now exported in immense quantities to the China market.[1] The vine grows to great perfection among the rocky heights of Palestine, and in the mountains of Syria, where wine of a good quality is made, and also in Arabia. Industry and skill are alone necessary to improve the advantages of nature, and to render this precious produce a valuable article of commerce. The cotton shrub, which yields so useful an article of clothing, has from time immemorial been naturalized in India, growing in Arabia, Persia, and throughout Asia Minor; and the mulberry, which affords so splendid an article of dress, is cultivated with success in Syria, Mesopotamia, and Armenia. Flax and hemp are common throughout both Southern and Western Asia, and they would grow also in Northern Asia if the inhabitants knew how to profit by the advantages of the country. Indigo is another important article, which is cultivated in India and in some parts of Syria, as well as in Arabia. The Asiatic islands have been long celebrated for various aromatic plants; and the juice which exudes from the trunks of the smaller trees is of the richest fragrance. Among the species of laurels which abound in the southern parts of India and Ceylon we find those which produce mace, cassia, and camphor; and, lastly, the cinnamon tree, formerly supposed to be a native of Arabia; also the clove and the nutmeg trees. The balm of Mecca is the finest of all the gums, and diffuses an exquisite perfume. Arabia has also been long celebrated for frankincense and myrrh. Asia furnishes also many plants used in medicine, as well as in dyeing, such as the castor-oil plant, the senna, the aloe, and others, which extend all over the southern parts and through Asia Minor.

In Southern Asia the forests abound with the most valuable trees, with the most durable woods, and with every variety of ornamental and dye woods. The teak tree, which grows in the woods of India, surpasses all others in hardness and durability. There are many trees which minister to the subsistence of man. All the palms, for example, distil a rich and nutritious juice; that of the sago palm, distinguished for its beauty and spreading foliage, is so thick and nutritious, that it is used in this country as a medicinal and wholesome diet. The fan palm, which grows in some parts of India, is remarkable for the breadth of its leaves, one of which is sufficient to cover a dozen of men, and two or three to roof a cottage. The bread-fruit tree, which grows in India, yields a farinaceous fruit resembling bread prepared from grain. All the common fruit trees of Europe are also found in the hilly parts of India. Asia Minor and the banks of the Euphrates abound in the myrtle, the laurel, the turpentine, mastic, tamarind, cypress, sycamore, and other trees. The oriental plants are numerous in Persia; and in the Syrian mountains the oak and the cedar, celebrated in ancient times, grow to a great height. In the northern countries of Asia the trees most prevalent are the oak, the ash, the elm, &c.; and still farther north there is the dwarf birch and the mountain willow; also the pines and the firs, which rear their tall heads, and spread over the scenery their permanent hue of dark green. The strong and glutinous liquid which exudes from these northern trees is converted into tar, pitch, and turpentine, and becomes a valuable article of commerce, useful for many purposes.

All the most delicious fruits are raised in the tropical countries of Asia. Those most celebrated in India are the guava, the jambo, the mango, and the pine-apple; many others might be raised if garden-cultivation were attended to as it might be in that country. Syria, Palestine, the banks of the Euphrates, and Persia, are famous for the variety of their fruits, and produce abundantly pomegranates, oranges, lemons, almonds, peaches, figs, quinces, olives, walnuts, and melons of all sorts. In the neighbourhood of Damascus all the fruits of Europe arrive at maturity; and near the Caspian Sea there are whole forests of chesnut trees. The date tree, the fruit of which is in many parts the chief subsistence of the inhabitants, grows in Persia, Mesopotamia, Arabia, Syria, and Palestine. In the higher parts of these countries other fruits are to be found, namely, the apple, the pear, the cherry. In Northern Asia horticulture is little practised; and, excepting wild berries, few other fruits are to be seen in its desert and inhospitable plains. Flowers of all sorts, in the most splendid profusion and variety, and of the richest fragrance, adorn the country in Southern and Western Asia, and give it the appearance of a flower-garden. On such a subject, however, which presents so wide a field of inquiry, we cannot enter into details, which would hardly prove satisfactory to the general reader, and still less to the man of science.

[1] Minutes of Evidence before Committee of House of Commons on China Trade.

Asia. Animals.

The desolate tracts of thick jungle and dense forest which abound in Asia afford extensive cover for wild animals, which are accordingly found in great numbers, and comprise all the known *genera* of the globe. The lion is found in Persia, Mesopotamia, on the banks of the Tigris and Euphrates, and was formerly known in Asia Minor, but has now either entirely disappeared, or is rarely seen. It was not supposed that this formidable animal haunted the forests and jungles of India. But of late lions have been seen in great numbers in the north of India, in Guzerat, and in the province of Delhi, to the north of this place.[1] The tiger is a native of Asia, to which continent he exclusively belongs, having never migrated into the other regions of the globe. He is spread over all parts of Southern Asia, from the islands of the Indian Ocean, where he exists in amazing power and ferocity, to the great ridge of the Himalaya Mountains.[2] His progress northward is checked by the increasing cold; yet is he found in some of the higher regions, where ice is seen during the winter. It is certain, however, that he is a native of a hot climate; and it is probable, therefore, that when he feels the approach of winter, he will retire from the cold of the high country into the warmer and lower valleys of the south. Tigers are seldom seen in the countries westward of the Indus, though they may occasionally stray from their native haunts along the west of that river into the mountain tracts of Belochistan.[3] The tiger is not found in Persia, Arabia, or in any part of Africa, though it is quite certain that the country is quite congenial to his constitution and habits, and that if he could once reach it he would quickly propagate his race through its deep forests. Yet the lion reigns supreme in the woods of Africa, while the tiger is the lord of the Asiatic jungles. It would be curious, if we had materials for such a speculation, to trace the distinct regions of the globe which are occupied by the various animal and vegetable tribes. Plants, we know, are transported from the countries in which they are indigenous, and flourish in another soil and climate equally congenial; and, in like manner, the animals of one country have been transported with equal success to other countries, where they have multiplied. The wild and ferocious animals it is the object of man to destroy rather than to increase; and they would therefore receive no aid from him in their migrations from one region to another. Hence we find that those countries which are widely separated, and which present no practicable communication for animals, have each its own peculiar and distinct class. America has an entirely different race of animals from Africa or Asia; while the animals that are found in the islands or continent of Australasia (New Holland), resemble those of no other quarter of the world. The zoology of Asia and Africa, from their vicinity, and from the comparatively easy communication between them, does not present such diversities; yet it is remarkable, that while the lion is common over all Africa, the tiger has never yet been seen; while in Asia it is just the reverse, the tiger, and not the lion, being the more common of the two. There can be no reason, we should imagine, why the tiger should be confined to Asia, while there are other countries equally suited to his habits, except that, being indigenous in the regions of Eastern Asia, he has never been able to cross the barrier of mountains and deserts by which these regions are separated from Persia on the west. Beyond the western banks of the Indus the country is mountainous and impassable, and the climate extremely cold; the ridges from the Himalaya Mountains extending southward nearly to the sea, and the country beyond being merely a narrow strip of hot and sandy desert. Beyond this, farther to the west, extensive deserts are found, destitute of water and of all traces of vegetation, which would as effectually oppose the passage of wild beasts as the trackless ocean which divides Africa and America, and leaves to each its own class of indigenous animals. The other wild animals of Southern Asia are leopards, hyenas, jackals, tiger-cats, wild boars, antelopes, elks, red and moose deer, foxes, hares, mangooses, ferrets, porcupines, &c. All these are to be found in the southern plains of Asia. The hyenas, wolves, jackals, and bears, abound in some of the hilly tracts, and in the mountains of Belochistan and the other countries to the west of the Indus. The three first make dreadful havock among the flocks. The same animals are found in Persia, Mesopotamia, in Asia Minor, and in Palestine; and it is said that the lion is occasionally seen on the banks of the Jordan. The ounce is a formidable animal in these countries and in Syria, and is sometimes mistaken for the tiger. The timid zebra is found in the depths of the Persian forests.[4] The wild dog is common in Northern India, in Belochistan, and in all the mountainous countries to the east of Persia. It is a large and powerful animal, and extremely ferocious. They hunt in packs of 20 or 30, and frequently seize a bullock, which they kill in a few minutes.[5] The bones and remains of tigers, supposed to have been destroyed by the combined attack of these animals, are also sometimes found in the woods of Northern India.[6] The wild ass is a native of Persia, and is remarkably wild, and fleet in its movements. It is also common in the northern mountains of India, and in the countries to the west of the Indus. The wild sheep and the wild goat are common among the mountains.

Of the domestic animals, the elephant claims the preeminence, being unequalled by any other animal for the purposes of draught. This animal is confined to the southern countries of India, where the climate is hot, being seldom seen in the mountainous tracts towards the north. The camel is used for domestic purposes over a far wider extent of country than the elephant. This animal is of two species, the one with two humps, and the dromedary with only one hump; and it is domesticated all over India and the mountainous countries to the north of the Himalaya ridge, in Balk or Bactria, in Buckharia, in Tartary, in all the countries bordering on the Caspian Sea, even in the southern provinces of Europe, in Persia, Asia Minor, and the countries bordering on the Black Sea, and in the Arabian deserts. The two-humped camel is a remarkably useful animal for burden, being heavy in his make, with enormous bones, shaggy coat, amazing strength, and incredible patience of fatigue and of thirst. The dromedary is chiefly used for travelling, and its valuable quality is swiftness, by which, joined to its capacity of enduring hardship, it is qualified to travel at an incredible rate for many successive days. In all the low countries, especially in the dry and sandy tracts, such as Arabia, Syria, &c. the dromedary is employed. The two-humped camel is a native of the high countries in the neighbourhood of the Oxus and the Jaxartes, where it is

[1] Elphinstone's *Account of Cabul*, p. 141. [2] Bishop Heber.

[3] See Pottinger's admirable account of the countries of Belochistan and Sinde, chap. vii. which is replete with interesting information. The journey of this officer and of Captain Christie, from India to Persia, through these wild tracts, inhabited by hordes of robbers, may be considered a most perilous and honourable achievement, worthy of the greatest travellers.

[4] Kinneir, *Memoir of the Persian Empire*, p. 42. [5] Pottinger's *History of Belochistan*, chap. vii. [6] Bishop Heber.

still chiefly used. So large a portion of Asia is occupied by vast plains and wastes of sand, that its interior intercourse must be maintained by land journeys. But without the aid of the camel it would be impossible to traverse extensive deserts, destitute both of food and water; and in those arid countries such an animal, which has been truly called the *ship* of the desert, is the most valuable gift which Providence could bestow.

The other domestic animals of Southern and Western Asia are horses, mules, asses, buffaloes, black cattle, sheep, goats, &c. Arabia may be considered the native country of the horse, in which he arrives at the highest perfection, and combines all the most estimable qualities of symmetry of form, fineness of skin, fire, docility of temper, fleetness, and hardiness. It is chiefly from the Arabian breed that the horses in other parts of the world have been improved. In Persia the horses are neither so graceful nor so swift as those of Arabia, being high, with long legs, spare carcasses, and large heads; but they are highly prized by the inhabitants for their extraordinary capacity of enduring fatigue. To the east of Persia, at Herat, the breed of horses is fine; also on the banks of the Indus and its tributaries; and in the higher regions of Balk and Buckharia they are excellent and numerous, and are exported in great numbers to Hindostan.[1] The mule and the ass, all over India, are miserable animals. The mules are of a better quality in the Punjaub, on the upper course of the Indus, and they improve still more farther west. In the countries west of the Indus they are superior to those in Hindostan, and in Persia there is still a finer breed. But the mule of the east is inferior to that of England. The ass partakes of a similar improvement in his progress west, and is a far finer animal in Western Asia than in Europe. In Syria, Palestine, and generally in Asia Minor, he is distinguished by agility, fire, and patience of fatigue, and ranks in the first class of domestic animals. Buffaloes are found in the hot plains of Asia, as well as in the mountainous tracts; and the oxen which are used in the plough have all a hump on their backs. The wealth of the pastoral tribes who rove about in the western plains of Khorassan, and in the hilly tracts of Afghanistan, consists chiefly in sheep, which have tails a foot broad, and composed entirely of fat, and in other respects resemble the English sheep, being better and handsomer than those of India.[2] Goats are common all over Asia, especially in the mountains, where there are some breeds with curiously twisted horns; and they are by no means scarce in the plains.

In the northern parts of Asia, and in the high mountain tracts, a different class of animals is to be found. These cold regions are not distinguished by the same profusion of animal life as the tropical countries. The beasts of the forest decrease in numbers, in size, and also in fierceness; and the wolf, the bear, and the wild boar, are the only ferocious animals which thrive in these northern climates. In advancing on the desolate plains of Siberia to about the 60th degree of N. lat., we find the cold still taking effect on the animal as on the vegetable creation, and the living creatures as well as the plants and trees stinted in their fair proportions. Beyond this limit a different order of animals appears, protected against the severity of the climate by a thick covering of fur, which is sought after as a rich article of dress in more opulent countries. These animals are accordingly hunted for their skins, which constitute the great staple article of trade in Northern Asia. In the Arctic regions the bear seems to form the only exception to the diminished grandeur of the animal creation. This animal, nourished in the regions of perpetual snow, acquires a larger size and far greater power and fierceness than in southern climates. The domestic animals of the northern and mountainous countries of Asia are of a less imposing appearance, and not nearly of the same strength as those in the lower valleys of the south and west. In the high and cold plains of Central Asia the camel is no longer used as a beast of burden, nor in the northern parts of the continent. Thibet, Tartary, and the plains to the north of the Altai Mountains, are mostly inhabited by Tartar tribes, whose wealth consists in their cattle, which not only furnish them with food, clothing, and shelter, but are also used as beasts of burden, and in the labours of agriculture. The yak of Tartary, or the bushy-tailed bull of Thibet, seems to supply the place of the camel in these mountainous countries. This animal is about the size of an English bull, of great strength, and is reckoned a valuable property among the itinerant hordes of Tartars, to whom it affords the means of easy conveyance, of clothing, and shelter for their tents, from the prodigious quantity of long flowing glossy hair on its tail, and finally of subsistence from its milk and flesh. In those mountains is also found the musk-deer, which delights in the most intense cold, and of which the musk, a secretion by the male, affords a revenue to the government, as well as a valuable article of trade. Here also, on the highest mountains, amid ice and snow, is the Cashmere goat, the wool of which affords the materials of the finest shawls.[3] Wild horses are seen in the high plains of Thibet; and the breed of sheep, a peculiar species of which is indigenous to the climate, is of great value. They are nourished on the short and dry herbage of these exposed plains, and serve for subsistence to the inhabitants, as well as for beasts of burden. The wild and extensive plains of Tartary are inhabited by pastoral tribes, who depend in like manner on their herds. On the southern side of the Altai Mountains we find the same tribes of wanderers, most of them the scattered remnants of the Tartar nations who had formerly so deep a share in the great revolutions of Asia. All these tribes subsist chiefly by pasturage. Near the Ural Mountains some live chiefly by hunting or ensnaring the elk and other wild animals for their furs. Among those who are shepherds, sheep and horned cattle are found; while the hunting tribes have scarcely any domestic animals. In all these countries the wolf and the bear are known to abound. In the rigorous climate farther to the north, where the cattle are stunted in size, and can scarcely subsist, their place is supplied by the rein-deer, a species peculiar to this rigorous climate, and most valuable for all domestic purposes, whether for draught or for subsistence. During part of the year the inhabitants of those desolate countries subsist upon its flesh or milk, its skin furnishes them with the chief part of their dress, and its horns with such domestic utensils as they require. The dog is also trained to draw the sledge.

The feathered race in Asia includes almost every known species. In the southern parts are found all the tropical birds, distinguished by the most beautiful plumage, and some of them uttering sounds that have a resemblance to the human voice. Here are also found some of the largest and rarest birds,—the ostrich, the cassowary, and in the Himalaya Mountains the condor, one of which, shot by a British officer, is stated by Bishop Heber to have measured from the extremity of one wing to another the enormous length of 14 feet. The other birds are

[1] Elphinstone's *Account of Cabul*, chap. vi.

[2] *Ibid.* p. 143.

[3] Turner's *Embassy to Thibet*, p. 186.

eagles, kites, vultures, magpies in the higher countries, hawks, crows, wild geese and ducks, flamingos, herons, bustards, florikens, rock pigeons, lapwings, storks, plovers, snipes, quails, partridges, different species of the ortolan tribe, and almost all the other small birds to be found in similar climates. In Northern Asia the feathered creation is nearly the same as in Europe.

The principle of life, which is so active throughout the torrid zone, and produces quadrupeds of the most enormous size, is also visible in the magnitude and numbers of the reptile tribe, many of them armed with the most fatal poisons, all of them odious to the sight, and some, such as the boa constrictor, attaining the length of 30 feet, and of such prodigious muscular strength as to coil round and crush the largest animals to death. The influence of cold is adverse to the growth of these serpents, which are not found in Asia to the north of the Altai Mountains. The shark, which is found in all warm climates, haunts the tropical seas of Asia; and the crocodile, which is a different animal from the alligator of America, though equally powerful and ferocious, infests the rivers. All sorts of insects, namely, musquitoes, ants, gnats, flies, &c. most of them noxious and destructive, swarm in the torrid regions of this continent. During the short summers of Northern Asia the musquito and other insects abound in the woody tracts of Siberia, insomuch that near the Ural Mountains the peasants burn constant fires before their cottages, as a defence against their attacks.[1] But the locust, which is peculiar to certain parts of Asia, is the most mischievous of all these winged creatures. They light upon a country in a cloud which darkens the air, and leave nothing green behind them; fields sown with grain being utterly laid waste, and trees stript of their leaves, and of all power to ripen their fruits. They overspread the country with an appearance of blackness for many miles; and when they are driven by the winds into the sea, their dead bodies cover the shore in heaps. These destructive animals appear occasionally in the countries to the north and west of the Indus, in Belochistan, in the desert tracts of Khorassan, and in Persia.[2] They are sometimes seen in Arabia in countless swarms; and frequently to the north of the Altai Mountains, at the sources of the Irtisch, whence they extend their destructive flight as far as the Crimea and the southern provinces of the Russian empire.[3]

Historical sketch of the Asiatic nations.

Asia has been subject to more awful revolutions than any other part of the world. Though it was at a very early period the seat of flourishing kingdoms, it was soon desolated by war. Its wealthy cities, sacked by their conquerors, fell into decay and ruin; and many of its countries, once civilized and populous, now languish in desolation from violence and misrule. The mighty revolutions which have shaken this continent form an interesting subject, on which volumes might be filled. All that we can propose is a historical sketch of the great leading events which distinguish the annals of Asia, with a brief notice of the various nations which have flourished, or are now to be found within its limits.

Nineveh, Babylon.

The early history of Asia, like that of all other countries, is lost in antiquity; and the obscurity is but slightly dissipated by the indistinct accounts which we receive from the Greek historians, and the brief notices in the sacred volume, of the Assyrian and Babylonian empires. The Assyrian empire appears to have been established by Ninus or Belus, the Nimrod of the Scriptures, who, we are told, began to be mighty on the earth, and the beginning of whose kingdom was Babel or Babylon.[4] It was farther enlarged by the renowned queen Semiramis, who carried her arms into India, and extended her sway from the Euphrates to the Indus. The great city of Nineveh had its origin about the same time as Babylon. Sardanapalus was the last king of the Assyrian empire, which subsisted, according to some historians, 1300 or 1450 years. But Herodotus fixes its duration, on what authority does not appear, at 520 years. Sardanapalus was dethroned by Arbaces, governor of Media; and on the ruins of this kingdom two others arose, namely, the empire of Nineveh, under Arbaces, formerly governor of Media; and the empire of Babylon, under Belesis, the former governor of that city. Nineveh was the capital of the former empire, which embraced the countries on the upper course of the Euphrates and Tigris, and also the country to the east. To the empire of Babylon belonged Chaldea, including the lower valley of the Euphrates. This revolution took place in the 747th year before the Christian era, and in the 7th year after the building of Rome.[5] Some are of opinion that three kingdoms arose on the ruin of the Assyrian empire; but this is generally considered to be an error, the two supposed kings, Arbaces and Tiglath-Pileser or Ninus the younger, being the same person.

It is conjectured that the cities of Babylon and Nineveh were begun about 100 years after the flood, or in the year of the world 1771. At the same time we have no data for fixing with accuracy the chronology of this early period; and the different opinions held by most learned writers sufficiently mark the uncertainty of history in those ancient times. It would appear, however, that the fertile countries of Asia were rapidly overspread with inhabitants. Abraham, according to the Jewish chronology, was born 290 years after the flood; and in his time we hear of the cities of Ur of the Chaldees and of Damascus, besides others which had arisen in the valley of the Jordan, the inhabitants of which devoted themselves to commerce and agriculture; and we are told that this tract of country was well watered, and was even as the garden of the Lord, like the land of Egypt.[6] But from the incidents related, it would still appear, that excepting the plains of Jordan, which were brought under cultivation, the country was occupied by pastoral tribes. Abraham, when he proposes to separate from Lot, in consequence of the strife of their herdsmen, tells him that the whole land is before him; and he gives him his choice of either going to the right or to the left with his flocks; an arrangement which was scarcely consistent with a high state of cultivation, and which could not have been afterwards proposed when the country was fully peopled.

The posterity of Abraham, who were settled in Egypt, having greatly multiplied in the course of 450 years, were at last permitted to depart; and having crossed the Red Sea, they pursued their triumphant march to the land of Canaan, expelling or extirpating the inhabitants. Thus was laid the foundation of the Jewish commonwealth, which became, in the prosperous reigns of David and Solomon, one of the most flourishing empires of Asia, extending on the east as far as the Euphrates, and having ports both on the Red Sea and in the Mediterranean.

Western Asia was in this manner occupied between the 7th and 8th centuries before the Christian era by the

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[1] *Voyage de Pallas*, tome ii. p. 369. [2] Pottinger's *Journey through Belochistan*, p. 129; Elphinstone's *Account of Cabul*, p. 145.
[3] Pallas' *Travels through the Southern Provinces of the Russian Empire*, vol. ii. p. 426.
[4] Genesis, chap. x. [5] Prideaux, book i. [6] Genesis, chap. xiii.

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great Assyrian empires of Nineveh and Babylon, and by the kingdom of Israel. The limits of the first two to the east and west are not accurately defined. The Assyrian monarchs sometimes carried their victorious arms eastward into Bactriana and to the Indus; but whether they ruled over these conquered countries is uncertain. Their empire, it is probable, extended westward into Asia Minor. On the shores of the Mediterranean, Tyre, with several other flourishing cities, had at a very early period attained to wealth and splendour. Arabia was, as at this day, inhabited by wandering tribes of shepherds and robbers; and other tribes of the same character had spread themselves abroad on the northern plains.

Rise of Media.

The great ruling powers of Asia were engaged in continual wars; and the Medes, having thrown off the Assyrian yoke, contended with the others for the dominion of the world. Having joined the Babylonians, they invaded the kingdom of Nineveh, already broken by repeated assaults, and took and burnt the capital, thus bringing to an end this great and ancient empire, which had flourished nearly 1500 years, and 135 years after its separation from Babylon. The rise of these formidable empires on the Euphrates was portentous to the peace and safety of the neighbouring states. The kingdom of Israel, weakened by the revolt of the ten tribes, was accordingly invaded by the Assyrian armies. Samaria was subdued; and Jerusalem, overpowered by the victorious armies of Babylon, was taken and utterly destroyed, and the people carried away captive. The overthrow of the Jewish kingdom took place 588 years before the Christian era.

Persian empire.

Persia did not at this period (A. M. 3405, B. C. 599) include more than one province of the extensive country since known under that name, nor did it contain more than 120,000 inhabitants. But it was soon after united with Media, under the vigorous rule of Cyrus; and that warlike monarch enlarged his dominions on every side. Having subdued the Lydians under Crœsus, the allies of the king of Babylon, and the other adjacent states in Asia Minor, he thence proceeded into Syria and Arabia, which he also subjected; and extending his conquests from the Ægean Sea to the river Euphrates, he finally advanced against Babylon, and, having taken that great city, put an end for ever to the Assyrian empire, which had been renowned from the earliest period of the world. The kingdom of Babylon had subsisted, after its separation from Nineveh, 209 years. It was overthrown 50 years after the destruction of Jerusalem, and 540 years before the Christian era.

Persia continued to rule over Asia for above 200 years, when its power was overthrown by Alexander the Great. His extensive conquests were divided among his generals, who renewed the strife for dominion which had been for a time extinguished by the ascendancy of Persia. Amid these contentions Parthia and Bactriana in the east rose to the rank of independent states. The Roman armies entered Asia about 200 years before the Christian era, and subduing all opposition, they finally established the dominion of Rome from the Hellespont to the eastern boundary of the Euphrates. By the decided triumph of this great power mankind obtained a fresh respite from the calamities of war. It was the first care of the Romans to cement by policy what they had gained by arms, and to establish order and tranquillity in all parts of their widely extended territories. From this period, accordingly, may be dated the commencement of that brilliant era of prosperity and repose enjoyed by this portion of Western Asia for nearly 700 years, the time which elapsed from its final conquest by the Roman armies under Pompey to its subjugation by the Saracens in the 638th year of the Christian era. The people, profiting by the singular felicity of their lot, devoted their attention to commerce and the arts of peace, and attained to a high degree of wealth and refinement. All the civil institutions of society flourished; science and literature were cultivated; and mankind, basking in the sunshine of domestic repose, seemed to enjoy the illusion of perfect happiness. It is estimated that 500 populous cities covered the face of the country. These were adorned with magnificent temples and other splendid monuments of art; and some of them, such as Pergamus, Smyrna, Ephesus, &c. and especially Antioch and Alexandria, rivalled in extent and magnificence the majesty of Rome itself.[1]

Hindostan and China.

After an interval of 500 years, the Persian monarchy was revived under the dynasty of the Sassanides.[2] In Eastern Asia the splendid and populous empires of Hindostan and China, though imperfectly known in Europe, had flourished for many centuries. The origin of the Hindoo power is buried in a remote antiquity. The first authentic notice of this mild and pacific people was brought to Europe by the officers who accompanied Alexander's expedition to India. Prior to the era of the Mahometan conquest in the year 1000, the Hindoos possess very imperfect materials for their history.[3] Hindostan comprehended then, as now, the extensive country bounded by the Indus on the west and the Ganges on the east, though we know but little of its boundaries or internal state. The origin of the Chinese, as of other nations, is hid in obscurity. They claim their descent from a very high antiquity, their history going back by tradition to the remote period of 40 centuries, and for 2000 years their annals are verified by the testimony of contemporary historians. It is quite certain, indeed, that long before the Christian era they had emerged from the barbarism of pastoral life, and were devoted to agriculture and commerce; that they had acquired wealth and prosperity, and were thoroughly instructed in all the arts and refinements of civilized nations.

The pastoral tribes.

The historical sketch which we have given above includes only the civilized portion of India. But a great proportion of her population were in ancient times shepherds, who dwelt in tents; and it is the more necessary to attend to the distinction between these two classes, as it will be found to illustrate the political history of Asia, and those stupendous revolutions which have not only shaken this continent to its centre, but have been extended to the remotest parts of the world.

It has been already mentioned that the vast table-land of Central Asia, though containing large tracts of desert, is nevertheless interspersed with fertile and well-watered valleys, which produce abundance of pasture; and the immense plain to the north of the Altai Mountains, which extends over the whole breadth of the continent, from the Eastern Ocean to the Volga, is one continued meadow, affording subsistence for innumerable herds of cattle. In all ages, accordingly, those plains have been inhabited by wandering tribes of shepherds, rude, ferocious, and delighting in war. It is finely observed by the Roman historian, that "the pastoral manners, which have been adorned with the fairest attributes of peace and innocence, are much better adapted to the fierce and cruel habits of a military life." Such, accordingly, has been the character of all the pastoral nations. They have been always

[1] Gibbon's *Decline and Fall of the Roman Empire*, chap. ii.
[2] Sir J. Malcolm's *History of Persia*, chap. iv.
[3] Rennel's *Memoir of a Map of Hindostan.*

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addicted to violence and plunder; and their predatory expeditions, whether for the plunder of individuals or of empires, have been invariably conducted with the same fierceness and cruelty. In a pastoral state every man is a soldier, and he is trained to war by his daily occupations. He is hardened in his body by continual exercise and exposure to the weather; in hunting the wild animals of the forest, he acquires skill in horsemanship and in the use of all warlike weapons; and in the perpetual migrations of his tribe, which must be carried on with the same order as the march of an army, he is trained to vigilance and discipline. These wandering barbarians were, besides, engaged, as may be easily supposed, in continual wars with each other. Here, as elsewhere, the usual scarcity of subsistence and of room would soon be experienced with the progress of population. Disputes would thence arise, and fierce contests, which would only terminate with the destruction of one or other of the contending tribes. Of such obscure wars we have no accurate account, though it is certain, that from time immemorial the work of mutual slaughter has been going on in the interior of Asia; and it is obvious that those vast multitudes, if they had been united under some able leader, who could compose or crush all domestic dissentions, might, in place of wasting their strength in intestine strife, have directed it against the civilized portion of the earth, where wealth presented a tempting prize to barbarian cupidity; and, accordingly, this was precisely the calamity by which mankind were at length overtaken. The world was to be disturbed by a conflict, not as heretofore between improved states, but between barbarism and refinement. The question was now to be decided, whether polished nations or barbarians should rule the world; whether literature, science, the arts, the improved institutions, and the whole order of civilized society, should be broken up and buried under an overrunning flood of savage hostility. From the earliest times the countries of Asia Minor, and some parts of Europe, were subjected to the irruptions of barbarians; but no permanent conquest was ever attempted, and the invaders were in general quickly repelled. Asia Minor was defended against the inroads of the Scythians by the Persian monarch; and Rome, in the lion-like vigour of her growing strength, quickly shook off such unequal adversaries. Whether, however, from the increasing population of the Asiatic plains, or from the greater political union of the different tribes, those attacks were renewed with more vigour than ever; and at times the mighty mass of population over the whole breadth of the continent seemed to be agitated by one movement; and, according as the impulse given was to the east or to the west, the kingdoms of Europe or the empires of Hindostan and China were swept by the tempest of invasion. Those formidable expeditions were attended with various results. In those states which were vigorously ruled, the discipline and tactics of civilized warriors proved an overmatch for the untutored valour of barbarians. But, on the other hand, when the people, enervated by ease and luxury, neglected the study of war, and trusted for safety to a mercenary force, the country was overwhelmed by its barbarian conquerors. The Chinese empire was overturned about 200 years before the Christian era, by an irruption of the Huns; the fertile countries on the banks of the Oxus, and of the Jaxartes as far as the Caspian Sea, which had attained to wealth and prosperity under the Macedonian kings, and had ever since been cultivated like a garden, were reduced by the white Huns, and under their sway Carisme, Buckharia, and Samarcand became the seats of industry and of flourishing manufactures, and the great marts of the Indian and European commerce; while the Roman territory in the west was repeatedly assailed, and finally overturned, by hosts of barbarians, who had quitted the crowded plains of Asia in quest of settlements to be won at the point of the sword.

Mahometan power.

It was about the middle of the 7th century that the Mahometan power emerged from the Arabian deserts; and the shepherds of those burning plains, inflamed by religious enthusiasm and the love of plunder, were equally formidable in war with their brethren of the north. Of all the invaders who, in this unhappy period, desolated the world, the Arabian tribes were the most fierce and cruel. Their religion enjoined the blindest intolerance; they were commanded to propagate their faith by the sword; and it was accounted a merit in a true believer to shed torrents of Christian blood. The track of Mahometan invasion was accordingly marked by the ruin of peaceful cities and by unsparing slaughter. In the course of two years the plain and valley of Syria was subdued by the Arabs or Saracens, whose conquests were soon extended over Asia Minor in the west and Persia in the east; and the country of Transoxiana, or the fertile plains lying on the Oxus and the Jaxartes, were, after several severe battles, reduced under the power of the caliphs, whose authority, a century after the flight of Mahomet from Mecca in the year 662, extended in Asia about 200 days' journey from east to west, from the confines of Tartary and India to the shores of the Hellespont, and in Europe as far west as the Atlantic Ocean.

The dominions of the Arabian princes, in their widest extent, were divided into provinces, under subordinate governors, who owned themselves the servants or slaves of the caliph at Bagdad, their temporal as well as spiritual ruler. In the decay of the supreme power, those rulers, under the forms of the most abject submission, had acquired independence; and the caliph remained at Bagdad the vain object of outward homage, while he was inwardly despised. The Persian kingdom was also detached from their dominion, being usurped by a new dynasty, and was extended from the Caspian Sea to the ocean. This dynasty, as usually happens in disorderly times, was supplanted by two families, who, making a division of the kingdom, ruled, the one over Khorassan, Seistan, the high plains of Balk on the northern side of the great Himalaya ridge, and the countries of Transoxiana, with the cities of Buckharia and Samarcand; and the other over the southern provinces of Persia, as far as the Persian Gulf, namely, Irak, Fars, Kerman, Khusistan, and Laristan. These families appear to have ruled in Persia for 125 years, namely, from 874 to 999. They were overthrown by the Turkish princes of the line of the Gaznevides, the founder of which was Subuctageen or Sebectagi, who, from a common soldier, rose to the rank of a petty prince, and fixed his residence at Ghizni. His dominions consisted chiefly of the tract of country which, after the division of Alexander's empire, composed the kingdom of Bactria, namely, the countries lying between the Caspian Sea and the Indus, and near the source of the Oxus. He invaded Hindostan, subdued Northern India and the province of the Punjaub, and rendered the princes of the countries tributary to the princes of Ghizni.[1] His son Mahmoud or Mahmud, who reigned in Persia about 1000 years after the birth of Christ, was still more famous for the extent of his conquests. He had extended his empire northward by the reduction of Buckharia; and he now determined, in the

[1] Sir J. Malcolm's *History of Persia*, chap. vii.

true spirit of Mahometan intolerance, to wage a holy war against the idolaters of Hindostan. At this period the Mahometans had effected no permanent settlement in Hindostan. The people were purely Hindoo, without any admixture of foreign manners; and the whole country along the east side of the Indus to Cashmere was ruled by a prince of the Brahmin race, and between whom and the kings of Delhi, Agimere, Canoge, and Callinger, a confederacy was now formed against the common enemy of their country and religion.[1] Mahmoud entered Hindostan in A. D. 1000, and having defeated the armies of the confederate kings, he reduced the province of Moultan. Eight years afterwards he penetrated into the heart of India, where his farther progress was opposed by the confederated princes of the country, from the Ganges westward to the Neerbuddah. But the fanatical invader was still victorious, and his progress was signalized by rapine and slaughter. The idols were all broken to pieces, the temples, many of them of the most beautiful architecture, were pulled down, and an immense spoil was carried away. In the course of his twelve expeditions into India Mahmoud extended his conquests to the Ganges; and when he died in 1028, his territories were of great extent. The annals of those disorderly times afford no very accurate data for ascertaining their exact limits, which are variously stated by writers of great authority. According to Major Rennel, the empire which he established comprehended the eastern, and by much the largest part of Persia, and extended nominally from the upper and western course of the Ganges to the peninsula of Guzerat, and from the Indus to the mountains of Agimere in Northern India.[2] Sir J. Malcolm assigns Georgia and Bagdad for its limits on the west and south-west; Buckharia and Cashgar on the north and north-east; and Bengal and the Deccan, as far as the Indian Ocean, to the east and south-east. But though a large portion of Hindostan was at this time overrun by the Mahometan armies, it was only the Punjaub, or the country of the five rivers, that was entirely reduced under any regular government, the other parts of the country being merely occupied by troops.

Turkish tribes.

The empire of Mahmoud declined after his death, owing to divisions and civil wars, but chiefly to the rise of the great Tartar or Turkish tribe of the Seljookee, so called from the name of their renowned chief Seljook, who, being banished by his khan or chief from Turkestan, passed the Jaxartes with his numerous followers, and settled in the plains of Buckharia, in the neighbourhood of Samarcand, where he embraced the Mahometan religion. It is only when those barbarous hordes emerge from the desert, and come into contact with civilized life, that we obtain any clear account of their migrations and history. Their contests with each other, and their obscure wanderings in the interior, are not chronicled among themselves, and are seldom known to other nations. Hence we have rarely any clear data for tracing their origin, or their early conquests, or the consolidation of many tribes into one great nation. It is certain, however, that the vast population of Asia, agitated by internal tempests, has been always violently driven on the great empires of China and Hindostan, or on those of Persia and Rome, and has either made a breach, or, if repelled, has assailed the civilized world at some other more vulnerable point. China has been in all ages an object of attack; and it is generally believed that the Turks, and especially that tribe of them under Seljook, had been driven by the Chinese and a tribe of Tartars from the high plains of Asia, a short time before they sought refuge in the provinces of Transoxiana. They were living near the territories of Buckharia when they first attracted the notice of the Sultan Mahmoud, the founder of the dynasty of the Gaznevides, who had advanced into Buckharia with his army, and was so impressed with the fine military qualities of their chief, the son of Seljook, that he induced them to cross the Oxus and to occupy the country of Khorassan.[3] He had soon reason to repent of this fatal error. Like all those wandering hordes, the Turkmans or Turks were shepherds or robbers. They either molested the neighbouring states by petty inroads, or, with the whole united force of the nation, they practised robbery on the great scale, seizing on kingdoms and despoiling nations. The first emigration of these eastern Turkmans is generally fixed in the 10th century. They became formidable to Mahmoud, and more especially to his successor Massoud, who, from inability to resist their progress, was forced to grant them lands. He was afterwards defeated by them in a general battle; and the victorious Turks, under their leader Togrul Beg, whom they had now elected king, invaded Khorassan, and finally expelled the Gaznevides, the descendants of Mahmoud, from the eastern provinces of Persia. They fled eastward towards the Indus, and established the Ghiznian empire in the south-western provinces of India. This empire was maintained with various success till about the year 1184, under the Ghiznian emperors.[4] It is difficult to give any accurate view of its limits, which in such turbulent times would naturally vary with the fortune of war. They appear to have embraced the eastern parts of Persia, the mountain country of Cabul or Afghanistan, and the Indian provinces of Lahore and Moultan. The Ghiznian dynasty was superseded by that of the Afghan or the Patan emperors, who completed the conquest of the greatest part of Hindostan Proper about the year 1210. Togrul Beg hastened to improve his victory over the Persian monarch. Turning his arms to the west, he invaded Irak, in the centre of Persia, and advancing westward of the Caspian Sea into Azerbijan, the ancient Media, he made his first approaches to the confines of the Roman empire. He afterwards proceeded to Bagdad, and by his conquest of that place he gained possession of the person of the caliph, who was treated with the most profound veneration. His successors Alp Arslan and Malek Shah extended the empire transmitted to them by Togrul Beg. They subdued the fairest portion of Asia. Jerusalem and the Holy Land, which flourished under the mild sway of the caliphs, was taken and pillaged by one of the lieutenants of Malek Shah; and it was the vexation and rapine to which the Christian pilgrims were exposed in their journey to Jerusalem under the barbarous rule of the house of Seljook, that inflamed the indignation of the Christian powers, and gave rise to those wild and warlike expeditions for the recovery of the Holy Land, known under the name of the Crusades. The empire of the Seljookian Turks extended, under Malek Shah, from Egypt and Syria to Buckharia, which he conquered as far as Samarcand and Kharisme. He received homage from the tribes beyond the Jaxartes, and compelled the

A. D. 1037.

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[1] See *Memoir of a Map of Hindostan*, xliv. Major Rennel's elaborate and masterly researches have thrown great light on the geography of this interesting portion of Asia.

[2] Major Rennel's *Memoir of a Map of Hindostan*, xlvi.

[3] De Guignes, *Histoire Generale des Huns, des Turcs*, &c. tome iii. livre 10.

[4] Dow's *History of Hindostan*, vol. i. p. 142; Major Rennel's *Memoir of a Map of Hindostan*, cxli.

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sovereign of Cashgar to offer up public prayers for his prosperity, to strike money in his name, and to pay him an annual tribute.[1]

Internal wars.

From this period till the invasion of Zinghis or Gheng-his Khan, which is 110 years, namely, from 1092 to 1202, Asia was convulsed by foreign and intestine wars. The death of Malek Shah dissolved the unity of his extensive empire, in which three new dynasties arose; while in many cases the provincial governors contended for supreme authority, and harassed the country by their mutual wars. It was during this era of division and weakness that Asia Minor, which was ruled by the dynasties of Iconium and Aleppo, was invaded by the hosts of the European crusaders, who rapidly subdued the country, took the holy city of Jerusalem, and extending their conquests over the hills of Armenia and the plains of Mesopotamia, founded the first principality of the Franks or Latins, which subsisted 54 years, beyond the Euphrates. Those European invaders retained possession of Asia Minor and of Syria for nearly 200 years. Exhausted at length by a long series of sanguinary services, and not receiving reinforcements from home, they were finally driven from all their conquests by the coalition of the Turkish powers.

The Turkish dynasty of the Seljooks continued for 158 years, or 215 years if we reckon from the time that the tribe first emerged from the desert under its leader Seljook. The sultan of Carisme or Kharisme, who ruled over the country situated between the Oxus and the Jaxartes[2] with delegated authority, profiting by the distractions of the neighbouring kingdoms, declared himself independent, and invading Persia with a powerful force, he defeated and slew the last of the Seljookian monarchs, and subdued the greater portion of their dominions. He extended his inroads over Syria, and had become the terror of the Ayoubite princes and the sultans of Iconium; and he finally established his wide dominions from the Persian Gulf to the borders of India and Turkestan.[3]

Zinghis Khan.

The continued irruptions of those barbarous tribes into the regions of civilization had given rise to scenes of calamity and of revolution hitherto unequalled in the history of the world. Conquests had no doubt been achieved before by the warlike nations of antiquity, and the rage of war had been satiated by the ruin of peaceful cities and the massacre of the people. But these evils, great as they were, fell far short of those inflicted on mankind by the conquests of the pastoral tribes, which were carried to such a height by Zinghis Khan and his destroying bands, as nearly to threaten the desolation of the earth, and the extinction of all the arts, improvements, and civil institutions of society. This Tartar chief, or savage, who was originally the khan of a horde of shepherds, comprising 30,000 or 40,000 families, inhabiting the countries to the north of China, seems, about the beginning of the 13th century, to have united under his sway all the other tribes which, under the various designations of Huns, Turks, Moguls, or Tartars, wander on the spacious high lands and plains of Asia, between China, Siberia, and the Caspian Sea. He became, to use the expressive language of the great Roman historian, "the monarch of the pastoral world, the lord of many millions of shepherds and soldiers, who felt their united strength, and were impatient to rush on the mild and wealthy climates of the south." This great conqueror swept over the whole breadth of the earth with his barbarian hordes. Art and nature were found alike unequal to stay his destructive course. He traversed mountains and rivers, barren deserts and unhealthy climates, with resistless speed; and he oppressed the walled towns by his countless multitudes. The Chinese were the first enemies with whom, after quitting the desert, he measured his strength. His innumerable squadrons penetrated at all points the feeble rampart of the great wall. Ninety-six cities were plundered and destroyed, and the smaller towns and villages were reduced to ashes; the aged were given up to the destroying sword; a prodigious multitude of childern were carried away, who were afterwards massacred in the march homeward; besides a rich spoil in gold, silver, silk, and cattle.[4] In a second expedition he was equally successful; the emperor fled before his enemies to a more southern residence; Yenking or Peking was taken and burnt; and, through the weakness and division of the Chinese councils, the five northern provinces of the empire were reduced under the dominion of the Moguls.[5] The invincible arms of Zinghis were now turned against the sultan of Carisme or Kharisme, who, as has been already mentioned, ruled over the fertile countries situated between the Oxus and the Jaxartes, and had extended his conquests over a great part of Persia. At this period his territories contained the flourishing and commercial cities of Samarcand, Buckharia, Carisme, Herat, Balk, &c. His troops were overpowered in a bloody conflict with the Tartar host, the country was subdued, and the rights of conquest were as usual most savagely abused. The open country was desolated; the rich cities plundered, and the inhabitants either slaughtered or carried into captivity; and in some cases every thing that had life, with the city itself, was destroyed. The cities that perished in this general ruin were, Buckharia, situated on a branch of the Jaxartes, a populous city, the centre of an extensive commerce, and the seat of science and religion; Otrar; Cojend, on the Oxus; Samarcand, situated near the source of the same river as Buckharia; Carisme, where 100,000 men were massacred, and the surviving population reduced to slavery; Balk, on the Upper Jaxartes, which contained 200 splendid mosques, and a numerous population; Nisabaur; Herat, in Khorassan; Candahar, farther east; besides numerous other smaller towns and villages. All that tract of country which extends from the Caspian Sea to the Indus, comprehending the ancient territories of Transoxiana, Carisme, and Khorassan, and which was fertile, populous, and well cultivated, was entirely ruined by this irruption of the Tartars, so that, to use the words of the Roman historian, "five centuries have not been sufficient to repair the ravages of four years." The conquests of Zinghis, before his death, extended west from the Indus to the Euxine, from the Pacific Ocean to the Volga, and from the Persian Gulf to the confines of Siberia. A. D. 1227

The children of Zinghis, who succeeded him, completed the career of conquest which he had begun. China, divided at that time into the two dynasties or empires of the north and south, was subdued and laid waste by his grandson Cublai, with all the unrelenting cruelty of a Tartar conqueror; and he extended his influence and the terror of his arms over the circumjacent kingdoms of Corea, Ton-

[1] D'Herbelot; De Guignes, *Histoire des Huns*, tome iii. livre 14.

[2] De Guignes, in his learned and laborious work *Histoire des Huns*, gives a very clear narrative of the situation and boundaries of this kingdom, and of its final ruin by the invasion of Zinghis Khan. The fate of the sultan, formerly a conqueror, who, flying from the Tartar horse, took refuge in an isle in the Caspian Sea, where he requested a horse might be allowed to feed near his tent, as the companion of his solitude, and his solace in adversity, is particularly touching. See tome iii. livre 14.

[3] De Guignes, *Histoire des Huns*, tome iii. livre 10.

[4] *Ibid.* tome iv. livre 15.

[5] Gibbon, vol. xi. chap. 64.

quin, Cochin-China, Pegu, Bengal, and Thibet. A new dynasty of Mogul princes was established in China, under whose sway the country gradually settled; and in the succeeding generation the habits of the invaders were mollified by the influence of civilized life. Letters, commerce, and the arts of peace were revived, and the ancient system and machine of Chinese manners and policy resumed its accustomed action. One hundred and forty years after the death of Zinghis, his degenerate race were expelled by a revolt of the Chinese, and the native dynasty of princes, namely, that of Ming, was elevated to the vacant throne.

Persia was overwhelmed by the invasion of the Tartar armies under Holagou Khan, the grandson of Zinghis. The princes who ruled in the different districts of the country, under the titles of sultans, emirs, and attabeks, were successively crushed under this great conqueror, who, advancing to the Euphrates, stormed and destroyed
A. D. 1258. the city of Bagdad, put the caliph to death, and thus for ever extinguished the line of the Abassides. Syria was overflowed by the torrent of invasion; Damascus and Aleppo were given up to pillage;[1] the kingdoms of Armenia and Anatolia were overthrown; and the sultans of Iconium, the last remnant of the Seljookian dynasty, were extirpated by the armies of Holagou.

The descendants of Zinghis had no sooner subverted the empire of China, than they resolved on the conquest of the western world; and collecting a mighty host, they advanced from China to Europe, inundating the intervening space with their innumerable hordes, and extirpating the reigning powers in Turkestan, Tartary, and the northern plains of Asia. They penetrated into Europe with their victorious armies, of which detachments were sent northward to contend with the Russian princes for the frozen regions of Siberia. The unity of the Mogul empire, so firmly maintained by Zinghis Khan, was weakened by the extent of its conquests. According to its original constitution, all the other khans were the dependents or vassals of the great khan, under whose investiture they held their authority. But by distance, and the various mutations of time, those ties of allegiance were gradually loosened. The different branches of the Mogul family conformed, from policy or conviction, to the religion of the conquered countries, those who ruled in China to the idolatry of the Chinese, and the invaders of the Moslem territories to the Mahometan faith; and from this diversity of religion and manners divisions arose, which terminated in a lasting disunion. From A. D. 1240 till the rise of Timour or Tamerlane, about the year 1360, the Mogul power in Western Asia was shaken by intestine strife; and a crowd of emirs, sultans, and petty rulers contended, in incessant wars, for the fragments of the broken empire; while such of the Moslem potentates as survived the invasion of Zinghis, still maintained, by their valour, the balance of power in Syria against their Tartar enemies. The Ottoman line of princes, the permanent rulers of the country, were in the mean time slowly emerging into view. Amid the anarchy which reigned in Western Asia from the downfal of independent powers, and the rise of usurpers in their place, the country swarmed with a warlike population, with loose disbanded soldiers, and adventurers of every description. Among these were many of the Turkman hordes who had formerly pitched their tents on the southern banks of the Oxus, and the khan of one of those obscure tribes was the father of the Ottoman dynasty. Othman was the first of this line who, about the year 1326, by his conquests, laid the foundation of the Turkish empire, which has ever since continued to rule in Syria and Asia Minor. About the year 1400 the Turks, under Bajazet, had acquired an extensive empire, the glory of which was for a time obscured by the conquests of Timour the Tartar, or Tamerlane, who began to acquire renown by his early conquests in Eastern Turkestan, or Transoxiana, about the year 1360, when he subdued the kingdom of Cashgar, and carried his conquests 480 leagues to the north-east of Samarcand.[2] He finally extended his dominion to the Irtisch and the Volga; and in 1398, having previously reduced the Punjaub and the province of Moultan, he advanced across the intervening desert to Delhi, which submitted to his arms, and was abandoned to pillage. He proceeded eastward towards the sources of the Ganges in a crusade against the idolatry of the Hindoos, who were massacred without pity; and, after an expedition of five months, he finally retraced his steps to Samarcand, without effecting any permanent conquest. In the western countries of Asia he encamped and overthrew the rising power of the Turks under Bajazet, and extended his conquests over Syria and Asia Minor, giving over its flourishing cities, such as Aleppo, Damascus, Smyrna, &c. to the sword and the flame. The rise and progress of this great Tartar chief, and his rapid successes, rivalled those of Zinghis himself; but they were not on the same vast scale, nor had they such lasting effects. The kingdoms which were conquered by Zinghis were colonized by his soldiers and inherited by his children; but Tamerlane's conquests were more like predatory inroads; and though for the time he subverted the existing order of things, and trampled in the dust the princedoms and powers of the country, yet, as the flood of his invasion receded, those powers quickly resumed their sway. In Asia Minor the Ottomans speedily regained their ascendancy on the ruins of the Greek power. They reared up, in the middle of the 15th century, the permanent fabric of their empire. Towards the end of the same century Persia was, by a singular revolution, transferred from the Tartar chiefs to the dynasty of Seffanean kings, or saints as they were considered before their elevation to the throne. Under their rule the country continued without any material change, until it was invaded in 1722, and conquered by Mahmood, the first of the Afghan rulers of Persia. The independence of Persia was vindicated by the rise of the celebrated usurper Nadir Shah, who, ascending the throne about the year 1730, quelled all internal dissensions, and re-established the Persian empire in its ancient greatness and glory. He restrained the Turks within the western boundary of the Euphrates; on the north he extended his dominions to the Oxus, and awed by the terror of his arms the Usbecs, and other wandering tribes of the desert; and on the east he conquered Hindostan, which he plundered of its wealth, and fixed the Indus as the boundary of his empire. Under his successors Persia has decreased in extent of territory and in power, but has not been subjected to any violent revolution, and still continues one of the independent though declining empires of the east. In 1747 the Afghans, under the new dynasty of the Doorannee kings, resumed their independence, which they still retain. Their kingdom is bounded on the east by the Indus, and on the west by Persia, or by intervening deserts.

Hindostan.

In Hindostan the influence of the Mahometan conquerors, which was firmly established in 1210, was gra-

[1] "Les hommes," says De Guignes (tome iv. livre 17), "les femmes, et même les enfans à la mammelle, furent égorgés."
[2] Gibbon, vol. xii. chap. 65.

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dually extended over the southern provinces, amid rebellion and massacre. The uncertain dominion of the country appears to have been shared among a crowd of tributary princes, who, from their intestine quarrels, became an easy prey to the invader. Delhi was the capital of the Mahometans; and their conquests were extended over Malwah, the Deccan (by which we mean the country between the Nerbuddah and the Krisna rivers) and the Carnatic, which was ravaged from sea to sea. The invasion, or rather the predatory inroad of Timour in 1398, did not subvert the Mahometan dynasty, which terminated in 1413 by the death of the monarch. The throne was then filled by a Seid, *i. e.* one of the race of Mahomet, whose posterity enjoyed it till the year 1450, when an Afghan took possession of it, and all Hindostan was divided into separate governments. After an interval of reviving prosperity, the empire, about the year 1516, fell again into utter confusion, which paved the way for the conquest of the country by Sultan Baber, a descendant of Tamerlane and of Zinghis Khan, who being driven from the provinces situated between the Indus and Samarcand, over which he reigned, determined to try his fortune in India. He crossed the Indus in 1518, and having defeated the emperor of Delhi, he established the dynasty of Timur, or the Mogul line as it has been termed, which was illustrated by two of the greatest princes that ever reigned in India, namely, 1*st*, Acbar, who, from 1555, reigned 51 years, and subjected to his sway all the provinces that had revolted, from Agimere to Bengal; and, 2*dly*, by Aurungzebe, who, after the interval of anarchy that continued for 50 years on the death of Acbar, ascended the throne in 1660, and died in 1707, in the 90th year of his age. In this reign the dominion of the Moguls was extended over the Deccan, the whole of which, excepting only the mountainous and inaccessible parts, was either entirely subjected, or rendered tributary to the court of Delhi.[1] His authority reached from the 10th to the 35th degree of latitude, and to nearly the same extent in longitude; and his revenue amounted to 32 millions sterling. The Mogul empire gradually fell to pieces under a succession of feeble princes; and about the year 1750 it was reduced to the city of Delhi, and a small tract of adjacent territory. The last imperial army that ever appeared in the field was defeated by the Rohillas in 1749; and during this period the whole country was one scene of commotion, all the viceroys and petty feudatories of the Delhi sovereigns,—the various mountain tribes, such as the Rajpoots, who ruled in Agimere,—the Seiks, who had become formidable, and had established themselves in Lahore,—and the Jats, a tribe also in the north of India,—contending in arms for independence. Nothing remains of Mogul greatness but the name, which was, and is still, used as the symbol of sovereignty, and the sanction of all political and civil rights.

The decline of the Mogul empire paved the way for the rise of the Mahratta power, which had already become formidable in India under its founder Sevajee. At his death in 1680 he had acquired considerable dominion on the western coast of India. The confusion and anarchy that followed the death of Aurungzebe greatly facilitated the Mahratta conquests; and in 1740 this growing empire, which was divided between two chiefs, the one residing at Poonah in the west, and the other at Nagpoor in the east, occupied the whole track from the western sea to Orissa, and from Agra to the Carnatic.[2] The Mahrattas, thus daily gathering strength, and the Mahometans, were now the two great rival powers in Hindostan. The contest between them was brought to an issue in the memorable battle of Paniput in 1761, when the Mahratta host of 200,000 men was entirely overthrown, with the loss of the greater part of their army, and their best generals; and from that fatal day their power began to decline.

Rise of the British power.

The rise of the British power forms an important era in the history of India. The unwarlike inhabitants of Hindostan, successively subdued by the Greek, the Mahometan, and the Tartar armies, were now destined even more surely to fall under the science and discipline of Europe. The French maintained their ground in India only for the short period of 12 years, from 1749 to 1761. The British, who engaged about the same time in the wars and politics of India, were more successful. The battle of Plassy, in 1757, fought with Surajah Dowlah, nabob of Bengal, gave them a firm footing in the country. The war which followed terminated in their favour; and in 1765 they acquired the right of collecting the revenues of Bengal, which was in fact the sovereignty of the country. The jealousies of the native powers, excited by the encroachments of the Europeans, gave rise to new contests. But victory was still the result of each new struggle; and all the wars undertaken against the British only tended to consolidate and extend their empire. The long and memorable struggle with Hyder Ali and his son Tippoo, who ruled in Mysore, terminated in their entire overthrow in 1799, and in the capture of Seringapatam, the capital of the kingdom. The peace of India, which was re-established by this decisive success, was not, however, of long duration. The British were regarded by the native princes as the common enemies of Indian independence. They were alarmed by their growing power, and they naturally united with each other against them. The British, on the other hand, viewed with equal jealousy the hostile dispositions of the native princes. They foresaw that a struggle would take place for the dominion of India, and they made suitable preparations for the impending crisis. A combination of the Mahratta chiefs Scindiah and the rajah of Berar was overthrown by the skilful and vigorous movements of Sir A. Wellesley. Holkar, who rashly measured his strength with the British, was also overthrown, and peace was re established. In 1817, when the British were prosecuting the war against the Pindarees, the Mahratta powers formed a new coalition, and took the field in great force. They were separately overthrown: the Peshwa, the head of the Mahratta states, was deprived of his throne, and his territories placed under the administration of the British. The rajah of Nagpoor was also driven from his dominions; and Holkar was again humbled, and deprived of his rank as an independent prince. This was the last expiring effort of Indian independence, by which the struggle was closed, and the dominion of the British firmly established, from Cape Comorin to the Himalaya Mountains.

Different Asiatic races.

Amid those revolutions, of which we have attempted to give a brief sketch, it is not surprising that some of the most ancient empires of Asia should have entirely disappeared; that populous cities should have fallen into decay and ruin; and that extensive countries, once the seats of wealth, commerce, and science, should now lie desolate. The Babylonians and Assyrians have been long blotted out of the page of history; and no traces of them remain in the population of the world. The kingdom of

[1] Dow's *History of Hindostan*, vol. ii.; Major Rennel, *Memoir of a Map of Hindostan*, Introduction, lxi.
[2] Major Rennel, Introduction, lxxxv.

the Jews has also been overthrown; but this ancient race are still wanderers on the face of the earth, and are found in most parts of Asia. There are other five principal races, who, it is remarked by Sir W. Jones, have in different ages divided among themselves as a kind of inheritance, and who still occupy, the vast continent of Asia, with the many islands depending on it. These are the Hindoos, the Chinese, the Tartars, the Arabs, and the Persians. The origin of those different races is a curious subject of inquiry, and must be sought for in the remotest antiquity, and from the doubtful analogies supplied by religion, manners, and language. Sir W. Jones, who has so well illustrated many obscure points of ancient history, is of opinion that Persia was the original seat of mankind, from which, as from a common centre, they have gradually spread over the earth. According to his learned hypothesis, deduced from ancient works and an examination of the primitive languages, a flourishing empire was established in Persia or Iran, in the earliest dawn of history; and the population consisted of the three distinct races of Hindoos, Arabs, and Tartars. About the era of Mahomet, it appears that, besides the language in common use, the learned had a language of their own, which had the name of the Pahlavi; and there was the still more ancient and abstruse language of the Zend, in which some sacred books were written, only known to a sect of priests and philosophers. The Pahlavi he clearly proves to be of Chaldaic origin, and the Zend, from an imperfect vocabulary which he procured, to be a dialect of the Sanscrit, the ancient and learned tongue of the Brahmins in India. Having thus ascertained the analogy between the language of the ancient Persians and that of the Arabs and the Hindoos, he concludes that they must have originally been the same nation; and that, as Persia could not be peopled from the east by the Hindoos, whose religion forbids them to emigrate, nor by the Arabs from the west, as we have not the slightest tradition of any such emigration, both Arabs and Hindoos must have come from Persia, since we may still trace in this country the remains of their respective tongues, all of which appear to have been derived from one common and more ancient root.

The people of Thibet are descended from the Hindoos, and, according to the hypothesis of Sir W. Jones, who on all those subjects unites solid reasoning with the most profound learning, have engrafted the heresies of Buddha on their ancient religion. Their language, though it has been corrupted by an intercourse with the Chinese, still bears the traces of a Sanscrit origin. The Afghans or Patans, who occupy Afghanistan, between Persia and Hindostan, are said to have sprung originally from the Jews; and their language, which is derived from the ancient Chaldee, so far confirms this tradition. The Japanese and the Chinese are evidently derived from a common stock, their literature, religion, and manners being the same. The Burmese are considered, on the best evidence, to belong to the Hindoo race, though others give them a Tartar origin.

The Tartars, under which appellation we include the hordes of shepherds who range over the vast plains of Asia, under the names of Scythians, Huns, Mongols, and Kalmucs, differ entirely from the Hindoos and Arabs in features, complexion, and form, as well as in manners and language, and appear evidently to be a distinct race. Their language, which is the Turci or the Turki, of which the modern Turkish is a dialect, might, according to Sir W. Jones, be easily traced to a different root from the others. This ancient Tartarian language he mentions, on grounds which it would not be easy to disprove, was current in Persia at a very early age; and hence he concludes that the Tartars formed part of the ancient population of Persia, and, along with the other two races, issued from that country to occupy the deserts of Asia. The Chinese, according to the same learned author, whose opinion is founded on the Sanscrit institutes of Menu, were originally a military tribe of the Hindoos, who, abandoning the ordinances of the Brahmin religion, and living in a state of degradation, emigrated eastward, and occupying the countries bordering on Hindostan, laid the foundation of the Chinese empire. But the whole country has been since overrun and conquered by hordes of Tartars; and from the intermixture of those two races have sprung the modern Chinese, whose coarse, broad, and Tartar-like physiognomy bears no longer the traces of their Hindoo ancestors.

We have no sure data to determine from what country the population of the world at first proceeded; and most of the theories on this subject rest chiefly on the doubtful analogies of language, or on other evidence equally uncertain. It is the opinion of many learned inquirers that the Chinese are not Hindoos; but that they, along with all the inhabitants of Eastern Asia, are originally a Tartar race. This opinion is founded on the usual evidence of a common origin, namely, a resemblance in features, language, and customs. Dr F. Buchanan, who travelled into the Burmese country, and has furnished some interesting information respecting this people, observes, that "there is one very extensive nation which inhabits the east of Asia, and that it includes the Eastern and Western Tartars of the Chinese authors, the Kalmucs, the Chinese, the Japanese, and other tribes inhabiting what is called the peninsula of India beyond the Ganges, and the islands to the south and east of this, as far at least as New Guinea." The features and figure of all those different nations which he describes indicate a Tartar origin. They are in stature short, squat, and robust; their face is sharpened towards the mouth and chin, while at the cheek-bones it is very broad. Eyebrows that scarcely project; narrow eyes, placed rather obliquely in the head; a very small nose, with the apertures of the nostril nearly circular; harsh, lank, and black hair, complete the portrait of a Tartar face. By such features they have been distinguished in all ages. The ancient writers, in describing the barbarians who invaded the Roman empire, particularly mention their small twinkling eyes, punctured as it were in their heads; their broad shoulders, short stature, and their shrill voices, which is not mentioned by Dr Buchanan as characteristic of the inhabitants of Eastern Asia.[1] There seems no reason to question those strong evidences of a Tartar origin; and admitting so far the theory of Sir W. Jones, that the Chinese were originally descended from a tribe of Hindoos, they appear in the course of ages to have lost all traces of that ancient race.

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[1] Ammianus Marcellinus speaks of their firm and compactly built limbs, their thick necks, their large and bent figures; and, in a tone of exaggeration, compares them to two-legged brutes, or to the rude figures which were placed by the Romans at the end of bridges. He mentions also the practice which prevailed among them of rooting out the hairs of their beard. "Ubi quoniam ab ipsis nascendi primitis infantum ferro sulcantur altius genæ, ut pilorum vigor tempestivus emergens corrugatis cicatricibus hebetetur, senescunt imberbes absque ulla venustate, spadonibus similes; compactis omnes firmisque membris, et opimis cervicibus; prodigiosæ formæ et pandi, ut bipedes existimes bestias, vel quales in commarginandis pontibus effigiati stipites dolantur incompte. (*Amm. Marcell.* lib. xxxi. cap. ii.)

The tribes who inhabit the great Asiatic archipelago, which extends from Madagascar to the Philippines and the neighbouring peninsula of Malacca, bear in their features, language, and customs the undoubted marks of the same origin; and as the Sanscrit may be traced as the root of all the various dialects spoken in these islands, they appear to be descended from the Hindoos. But in the lapse of ages, and in the various chances of war or migration, different nations may be intermingled; the original traits by which each was distinguished will then gradually disappear, so that it may not be possible to discern the traces of a common origin in the varieties of the same race. Like the Chinese, therefore, the inhabitants of the great Arabic archipelago may have come originally from Hindostan, bringing with them the Sanscrit tongue; and in the course of migration or conquest they may have acquired the features of the Tartars, without losing their native language. Sir Stamford Raffles, not less distinguished by his eminence in eastern literature and antiquities than as a legislator and a statesman, is of opinion that the Asiatic islands were peopled from that portion of the continent which lies between Siam and China. "The less civilized of the tribes," he observes, "inhabiting the islands, approach so nearly in physical appearance to that portion of the inhabitants of the peninsula which has felt least of the Chinese influence on the one side, and of the Burman and Siamese on the other, and exhibit so striking an affinity in their usages and customs, as to warrant the hypothesis, that the tide of population originally flowed toward the islands from that quarter of the continent lying between Siam and China. But at what era this migration commenced—whether, in the first instance, it was purely accidental, and subsequently gradual, or whether originally it was undertaken from design, and accelerated at any particular periods by political convulsions on the continent, we cannot at present determine, as we have no data on which to rely with confidence. It is probable, however, that these islands were peopled at a very remote period, and long before the Burman and Siamese nations rose into notice."[1] Mr J. Crauford, who resided for nine years in the Asiatic islands, and whose history of those countries displays extensive research, and a profound knowledge of eastern literature and antiquities, adopts a different hypothesis respecting the original population of the Indian archipelago. He describes the original inhabitants to consist of two races, one a brown-complexioned people, with lank hair, and in their persons short, squat, and robust, supposed by other writers to be Tartars; and the other, a negro race, of a puny stature and feeble frame, in complexion black, or rather sooty-coloured, with woolly or frizzled hair. The brown-coloured race compose the civilized portion of the people; and they have supplanted the negroes, who are constantly found in a savage state in Sumatra, Java, and Celebes, where civilization has made the greatest progress; while in New Guinea and other islands the negroes are almost the sole inhabitants. The origin of these two races, and the period when they settled in the Asiatic islands, is, according to Mr Crauford, buried in the remotest antiquity. The Tartar origin of the one race, though supported by many writers of learning, and the African origin of the negroes, is treated by him as absurd and unfounded. "Either hypothesis," he observes, "is too absurd to bear the slightest touch of examination. Not to say that each race is radically distinct from the stock from which it is imagined to have proceeded; the physical state of the globe, the nature of man, and all that we know of his history, must be overturned to render these violent suppositions possible." Dr F. Buchanan, Sir Stamford Raffles, and others, deduced the Tartar origin of those insular tribes from their form and features, which is the best evidence we can have where history is silent. The prevalence of the Sanscrit language in these islands has also, and with apparently some reason, been supposed to indicate the quarter from which the tide of population flowed; nor is it easy to see how the migration of a people from the continent of Asia into this archipelago is at variance with the "physical state of the globe, the nature of man, and all that we know of his history." Mr Crauford traces the various languages of the Asiatic islands to one common root. From this fact he concludes those islanders to have all sprung from one source, and he fixes on Java as their original place of settlement. Here he supposes they took up their abode when they were little better than wandering savages; whence they gradually spread over the other islands. Now it is on the same ground that others trace their origin to some continental nation of great antiquity. The language of a nation may throw light on its origin and its subsequent migrations; and in the present case it is admitted by Mr Crauford that there is a large infusion of Sanscrit in all the Polynesian tongues; that it is "a more essential, necessary, and copious portion of the insular languages than Arabic;" that it exists in "a state of as great purity as the articulation and alphabets of the archipelago would admit, nearly unmixed with any modern dialect of which it is a part, and apparently in a state of original purity;" and that it is "pure and abundant as each dialect of the same tongue is improved, and rare and corrupt as the language is common and popular."[2] Sanscrit words, according to those who are versed in both languages, abound in the court dialect of Java in the proportion of three to four, and seem to constitute its basis; in the Kami, or learned language of the priests, they occur still more frequently, and in their original purity; they are also common in the written language, and are found, though not so generally, in the ordinary dialect of the people. The existence of Sanscrit to such an extent in the languages of Java and the other islands, does not, according to Mr Crauford, prove that these islands were peopled by emigrants from Hindostan. He acknowledges that the fact of the Sanscrit not being mixed in their languages with any living dialect of India, is somewhat puzzling, and not easily reconciled to his theory; but on farther consideration, he thinks this fact tends rather to explain the manner in which it was introduced, which he ascribes to a few Hindoo missionaries or priests brought to those islands from a desire to propagate their religion. They would naturally, he supposes, use the Sanscrit in teaching the mysteries of their faith, which, being mixed with the common language of the country, would form the Kami or learned language of the priests, and would thence be diffused in a corrupted state over the common dialect of the people. From the prevalence of Sanscrit to such an extent in the Polynesian dialects, as well as from the ancient monuments of Hindoo idolatry which are found everywhere in those islands, it seems highly probable that they must, at a very early period, have been the seat of a Hindoo empire, which has disappeared in the lapse of ages, while the Hindoo superstition has been supplanted by the Mahometan creed. Whether this empire was established by conquest in that early period, while the Sanscrit was yet a living language, or whether the Hin-

[1] Sir S. Raffles' *History of Java*, chap. ii.
[2] *History of the Indian Archipelago*, by John Crauford, F. R. S., vol. ii. chap. v.

doos were the original settlers in these islands, and afterwards, from the intermixture of other races, lost the traces of their ancient lineage, are points which lie hid in the darkness of antiquity. It does not seem very credible, however, that a small number of Hindoo missionaries should have had influence, as Mr Crauford supposes, to change the language of the people, and to substitute for the ancient religion of the country their own foreign superstitions. So great a change seems more probably to have been produced by foreign conquest, or by a large emigration of the Hindoo people.

The Malays.

Of the various races which people those islands, the Malays appear to deserve particular notice. Sir W. Jones supposes them to be descended, since the time of Mahomet, from the Arabian traders and mariners who frequented the Asiatic archipelago. But by later and more accurate inquiries they are now ascertained to have been originally settled in Menangkabau, in the centre of the island of Sumatra, and to have ruled over the whole country, from which they sent out colonies to the other islands. The Malayan annals examined by Mr Marsden,[1] and other documents, satisfactorily prove that, so far from emigrating, as was generally supposed, from the peninsula of Malacca to the Asiatic islands, they were original settlers in Sumatra, from which they issued to invade and conquer the Malacca peninsula; and they had established a powerful empire prior to the Mahometan conquests. The Malays profess the Moslem creed, which was introduced about the end of the thirteenth century, and has made rapid progress among all those islanders. But their original religion was that of Brahma, blended with the antecedent rude idolatry of the country, such as is still seen among the Battas. The Malay adventurers who invaded the Malacca peninsula in the 12th century conquered the country; and the indigenous inhabitants, so far from being the stock from which the Malays have sprung, are an entirely different race, resembling more nearly the negroes of Africa. The Malayan empire, which extended all over Sumatra, is now dismembered, though its colonies have been found on the coasts of the Malacca peninsula, and throughout the islands as far east as the Moluccas.[2] The Malayan language is spoken without any mixture in the inland country of Sumatra; it is understood everywhere, and has extended over all the eastern islands. The Bugis in the island of Celebes are a well-known race in the eastern archipelago. During the flourishing era of the Malayan empire in Sumatra they had established that of Guah or Mengkasar in Celebes on the east: like the Malays, they sent forth numerous colonies; and at one period extended their conquests as far west as Acheen in Sumatra and Keddan in the Malayan peninsula; and in almost every part of the archipelago Malayan and Bugis settlers are to be found. In all those Asiatic islands there is, however, an indigenous race, who were settled there prior to the Malays or the Bugis; and these last appear to have been intruders, but at what period of the world cannot now be known. The native inhabitants of Sumatra, Java, and the other islands, differ from them in character, habits, and features. The Battas, in the interior of Sumatra, are a distinct people, with their own peculiar habits and language: they have been reproached by travellers for eating human flesh, of which Sir Stamford Raffles produces undeniable evidence. The natives of Java are a quiet, contented race, attached to the soil, and have not the roving, maritime, and piratical habits of the Malays.

Number of inhabitants.

With regard to the number of inhabitants in Asia, we have no data for any accurate estimate. The Asiatics possess no statistical knowledge; and, excepting surveys instituted by government for the purposes of taxation, no other political inquiries are ever set on foot by authority. The various accounts of the Chinese population differ to the extent of 100,000,000. Those regarding Persia, Hindostan, the Asiatic islands, &c. are little more to be depended on; and still less can we expect any accurate census of the roving population of Arabia or Tartary.

Character and manners of the Asiatic nations.

The character of the Asiatics is represented in a very unfavourable light by all travellers. Lieutenant Pottinger, who travelled in Hindostan, Persia, and other countries, asserts that moral turpitude may be said to pervade the population and society of every nation in Asia of which we have the slightest knowledge:[3] and this description is confirmed by other travellers, who describe the people to be dissolute in their morals, of cold and selfish dispositions, and withal cruel and treacherous; without any regard to truth, and indulging, without either restraint or shame, in the most scandalous crimes. Of all the nations in Asia the Persians are reckoned to be the most refined; and yet, according to Herbert, Chardin, and others, and more recently Fraser, Pottinger, and Sir J. Malcolm, they are stained with all the Asiatic vices of cruelty, meanness, lying, and the grossest licentiousness.[4] The Hindoos do not rank higher than the Persians in the scale of morality; and among the Burmese and other eastern states the treatment of women, who are held to be an inferior class, and are sold into slavery by their husbands and parents, and the cruelties which they commit in war, besides other revolting customs, indicate a state of manners which, contrasted with those of Europe, may be justly considered barbarous.[5] Of the low state of morals among the Chinese we need seek no other evidence than the inhuman practice, which is known to prevail in all the populous cities, of exposing new-born children to perish on the streets. There is no truer mark of barbarism than an indifference to the sufferings of our fellow-creatures; as on the other hand it is only in a highly civilized community that man is trained to the exercise of social benevolence. The savage is always found to be cold, unsocial, and selfish: in the progress of society this selfish principle is corrected; man is impressed with the duties which he owes to his fellow-men, and is taught to know experimentally, that it is not in the selfish pursuit of his own good, but in the mutual interchange of benefits, that the greatest sum of individual happiness is to be found. If we examine the manners, institutions, and policy of different nations, it will be seen that mankind are humane and moral exactly as they are instructed; and that as the diffusion of knowledge leads to the practice of all the social virtues, ignorance as surely produces cruelty, selfishness, and vice. Thus, among the Persians and Turks cruelties are committed which would be repudiated by the more advanced civilization of Russia; and in illustration of the same principle we may here mention a circumstance which serves to place in an equally striking contrast the manners of the English and the Chinese. An

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[1] *History of Sumatra.*

[2] Sir S. Raffles' *History of Java*, chap. ii.

[3] See *Travels in Belochistan and Sinde.* "I hope," he adds in a note, "I shall not be stamped as a misanthrope on account of the sentiments I entertain of all Asiatics. I am convinced the farther our researches spread, and the more intimately we become acquainted with the East, we shall discover stronger, clearer proofs of the general application of the conclusion I have drawn. I should be happy to have any evidence to the contrary, but do not anticipate it."

[4] See Fraser's *Narrative of a Journey into Khorassan.*

[5] See Crauford's *Journal of an Embassy to the Court of Ava in the year* 1827.

Asia.

English vessel happened to be at anchor in the roads of Canton, when a Chinese boat was overset, and the crew precipitated into the water. The accident was observed by numbers of the Chinese, who beheld with the utmost indifference their countrymen struggling for their lives. But the officers and seamen of the English vessel instantly lowered their boats, and were seen, with all their usual zeal in the cause of humanity, striving to save the lives of those who were entire strangers to them. Now we cannot have a surer index to the station which each nation holds respectively in the scale of civilization, than the opposite conduct which they severally pursued in this case; and this insensibility to human distress is not peculiar to the Chinese; it seems to pervade the whole population of Asia; while in Europe we see everywhere proofs of active benevolence,—the most munificent establishments for the relief of misery; hospitals for the sick and infirm; houses of refuge for the aged, the blind, the destitute, and the insane; besides charitable associations of every description. For all the afflictions to which frail humanity is subject, the active sympathy of Europe supplies a remedy; and the spacious structures which, under the influence of this feeling, have been reared up in all the European towns, are at once the splendid monuments of humanity and of high civilization. In Asia the rich and the powerful associate, not to relieve, but to oppress the poor; and throughout its wide extent no asylum for distress, nor any charitable institutions, are to be seen. The miserable are left to their fate, which is generally to die unpitied, either of famine or disease. There is no part of Asia in which intelligence is widely diffused among the people; and hence, while they are to "vice industrious," they are to "nobler ends timorous and slothful." Yet in the exterior pomp and show of the Asiatics there is something specious and imposing; and the rich magnificence of their flowing robes, their gorgeous palaces, their splendid mosques and gilded temples, are calculated to raise ideas of high improvement, which a nearer inspection fails to realise; and, after all, what is there in this tinsel glare of oriental luxury that can be compared to the severe simplicity and solid refinements of Europe.

This degraded state of society seems to be the joint effect of tyranny and superstition. In Asia there is no government which wears even the semblance of freedom. In form, as well as in practice, they are purely despotic, the princes being tyrants, and the people slaves. Nor is the power of the prince controlled by the influence of manners, as in Europe, where the monarch, however absolute, seldom indulges in the licence of despotic sway, and where life and property are fully protected. The manners of Asia favour the exercise of unlimited power; and this vast continent is accordingly one scene of excess and misrule, where the mere will of the monarch is a warrant for the proscription and death of any individual, however powerful, and for the ruin of his family. The people, ruled according to those severe maxims of despotism, live in continual dread of violence and wrong; and they naturally resort, in self-defence, to fraud, falsehood, and treachery, which are the resources of weakness. Thus all sense of independence is at last extinguished; and under the iron rod of their political masters they degenerate into abject slaves, without honour, intelligence, or morality. Despotism in Asia assumes so severe a character, that it invades the security of private life, relaxes all social ties, and re-acting on the people with its pernicious influence, tends still farther to debase them, and to fit them for the endurance of its degrading yoke.

The prevailing superstitions of Asia have had their due share in corrupting the manners of the people. In Asiatic Turkey, in Arabia, Persia, and partly also in Hindostan and the Asiatic isles, the people have adopted the Mahometan faith; in Hindostan they have followed the religion of Brahma; and in Thibet, and farther eastward among the Burmese, in China, and the isles of Japan, the religion of Buddha or Foe is universally established, which, however corrupted in its various forms and idolatries, is still known to be derived from the Brahminical faith. Now all those different systems enjoin a variety of minute observances, and tedious pilgrimages and penances, a strict compliance with which constitutes the essence of religion. A pilgrimage to Mecca, for example, atones for all the iniquities of a Mahometan life; and the Hindoos and others have their pilgrimages and penances for the expiation of guilt. A relaxation of morals is the consequence; and hence in those eastern countries a strict profession of religion is not inconsistent with the most scandalous crimes.

The sanction given to polygamy by all the systems of religion in the East has also tended to encourage licentiousness. Mahomet found it convenient to allow this indulgence to his followers; and the Hindoos, the Burmese, the Chinese, and most of the other Asiatic nations, follow the same rule. In all Christian countries marriage is respected as a sacred and an honourable tie, equally binding on both parties; and experience proves, that where its obligations are duly fulfilled, it is calculated to produce all the happiness and virtue which can be attained by man in this sublunary state. In the intercourse of a European family the best affections of our nature are called forth. Here, as the poet expresses it,

> Flows the smooth current of domestic joy;

and in those scenes the rising generation receive, from the example and tuition of parents, those just and early impressions, which are never erased. How different are the baneful consequences of polygamy, which, being contrary to the order of nature, must be upheld by tyranny, and which degrades the weaker sex, from being the free and equal companions of man, into the slaves of his pleasures. The domestic tyrants of the East rule with absolute power over all the inmates of the harem; any of whom, in a fit of rage or jealousy, they may consign to a cruel death, no eye witnessing the deed. The effect of polygamy in this manner is not merely to taint the morals of society, but the laws and policy of the state. It establishes a tyrant, not on the throne, which would be the lesser evil, but at the head of every family; and on his unruly passions the law imposes no restraint. Hence in Asia domestic comfort, so much prized in Europe, cannot be known. An Asiatic family is not the abode of purity and of domestic peace, but of licentiousness and strife; the husband and father the object of terror rather than affection; the women his abject slaves, leading a life of jealousy and malice, and often conspiring against each other by the most diabolical arts. The institution of polygamy, which in this manner converts one half of the community into tyrants and the other half into slaves, has proved, in every country in which it has been introduced, the bane of morality as well as of social peace. In Europe the purer influence of Christianity, consecrating the marriage union, and impressing on man a just consideration for the other sex, has raised them to the rank in society which properly belongs to them. It has released them for ever from the bondage of tyranny and vice; and under its mild and beneficent maxims the nations of Europe have attained to a degree of morality, refinement, and intelligence, which distinguishes them to their advantage above the most polished nations of antiquity, and presents a decided contrast to the licentiousness and misery of the East.

But if such be the state of society among the civilized inhabitants of Asia, what, it may be asked, is the condition

of its rude tribes? Among those semi-barbarians who have no fixed habitations, but who dwell in tents, migrating periodically with their flocks in quest of pasture, all crimes of violence, such as rapine, revenge, and murder, prevail without any restraint. The pastoral tribes of Asia retain all their Tartar habits of ferocity; robbery is their daily occupation, handed down from father to son; and they are perpetually engaged in predatory inroads, in which they carry off as their lawful prey all that they can seize—corn, cattle, goods, and men and women, who are sold for slaves. If any traveller were to venture within this region of violence, he would be robbed and murdered without mercy; and no merchandise can be transported from one place to another without a sufficient escort. The regular commerce of Asia is in consequence carried on in caravans, or large companies of merchants, who travel together for safety; and even these are not secure from the savage tribes, the remnants of the Tartar population, who inhabit the mountains and central plains, and who frequently emerge from their fastnesses in great force for the purposes of plunder. Such were the shepherds who, under Zenghis Khan and Tamerlane, issued forth in innumerable bands, subverting the great empires of the world, and extending their dominion from sea to sea. But various causes have concurred to circumscribe their power. Among these we may reckon the invention of fire-arms, which in war gives the entire ascendancy to civilized nations. Prior to this invention the weapons used were extremely simple, and could be easily fashioned by the rudest tribes. In archery, or in the use of the sling, the merest savages may excel; and for a close encounter the spear or the sword could be easily procured, and as effectually wielded by a barbarian as by any other arm. But the *matériel* of modern war is far more complicated and expensive, and cannot be procured without the aid of wealth, and the nicest mechanical art as well as science; so that it is justly observed by the historian of Rome, that in the present state of the military art, a nation must be civilized before it can conquer other nations. Since the invention of fire-arms the superiority of civilized over barbarous nations has been seen in every encounter which has taken place, and "the reign of independent barbarism has been contracted within a narrow span."

The extensive region of Tartary, which occupies the centre of Asia, has never been very distinctly defined; but it is surrounded on all sides by the civilized empires of Asia,—on the north by Asiatic Russia, and on the south by Persia, Hindostan, and China; and as the use of fire-arms has augmented the military strength of these different states, they have gradually extended their sway over the savage tribes on their frontiers. Russia, which was overrun by Tamerlane and other conquerors about the end of the 14th century, was, after about 200 years of obstinate and bloody wars, emancipated from the Tartar yoke; and it has ever since been making reprisals on its barbarous enemies, having reduced the tribes on its frontiers—the Kalmucs, the Bashkirs, the Kirghiscs, who inhabit the banks of the Volga and the country on the shores of the Caspian Sea, besides numerous other Tartar tribes on the Chinese frontier, near the sources of the Irtisch, the Obi, the Yencsei, and the Lena. Her wars with the Turks also, an Asiatic tribe, though of a different origin from the broad-featured race of Tartars, exemplify in a striking manner the warlike superiority of civilized nations. The contests of China with the barbarous hordes of Mongols, Kalkas, and Eluths, to the west and north-west of her territory, and with the Mantchoo Tartars, who inhabit the country to the north, bordering on the Pacific Ocean, have also terminated in their entire subjection. They have been successively subdued by the Chinese armies; and the missionary Gerbillon, giving an account of a great victory gained by the Chinese, ascribes it to the superiority of their artillery, which the barbarians had no means of opposing. Persia has been long a feeble power; and the Tartar tribes who range along her northern and eastern frontiers are still extremely powerful, and frequently molest the adjoining countries by their incursions. Independent Tartary may now therefore be comprised within the following boundaries, namely, the Altai Mountains on the north, which form the southern boundary of the Russian empire; the Caspian Sea on the west; Chinese Tartary on the east; and Persia and Hindostan on the south. These boundaries inclose a space of about 1200 miles in length, from the Altai Mountains to Persia; and 900 in breadth, from the Caspian Sea to Chinese Tartary. To this must be added the country between Hindostan and Persia, including Sinde at the mouth of the Indus; and westward the mountainous regions of Belochistan, as well as Afghanistan. In the high district of Balk, which is within this space, and which is situated on the northern declivity of the Hindoo Coosh or Himalaya Mountains, and in Buckharia or Bokhara, on the fertile banks of the Oxus and the Jaxartes, where are the towns of Buckharia, Samarcand, Khyvah, Koukan, Khojund, and Murghelan, &c. some form of civil order is maintained by the independent princes of the country; but with these exceptions the Tartar manners still prevail throughout this extensive region. The towns are thinly scattered, and the pastoral hordes range over the face of the land in all the licence of savage freedom. These consist, not of the Tartars who possessed the country in the time of Tamerlane, but of the Usbecks, a Turkoman tribe, who appear to have descended, with the whole mass of their people, from the inhospitable countries in the north, to the fine plains of the Oxus and the Jaxartes, and to have expelled the Tartars, whose place they now occupy. The Turkoman tribes, who inhabit the Elburz Mountains to the south of the Caspian, and the deserts of Kharasm, which extend eastward from this interior sea about 600 miles, are described by Fraser, in his instructive work on Persia, as singularly fierce, cruel, and blood-thirsty in their habits. They pour down from their deserts in great force on the cultivated districts, plundering villages and caravans with every circumstance of atrocious outrage, murdering on the spot the old, the feeble, and the helpless, and carrying into slavery those who are fit for labour, and thus depopulating extensive tracts that were before fertile and well inhabited. On the east of Persia the same ravages are committed by other tribes, who dispose of their captives to slave merchants, by whom they are carried to the markets of Buckharia and Khyvah. On the south the wild inhabitants of Belochistan, so well described by Lieutenant Pottinger, one of the most judicious and enterprising travellers of modern times, plunder and murder their prisoners, or carry them for sale to some of the great slave-markets in the East. Numerous tribes of shepherds feed their flocks on the banks of the Oxus and the Jaxartes; and they are found scattered over all the northern and eastern countries of Central Asia, as far as the boundaries of Russia and China. But in the present improved state of the military art they are no longer formidable, and they waste their force in casual inroads, which are easily repelled.

Progress of discovery in Asia.

From the earliest ages the countries of Western Asia, namely, Asia Minor, the valley of the Euphrates and Tigris, and Persia, were familiarly known to Europeans; but of the northern plains inhabited by the Scythian tribes, and of the rich and improved countries of Hindostan and China in the east, they were only informed by vague and inaccurate reports, which were slowly corrected by the progress of commerce or of conquest. Of the ancient

expedition of Semiramis into India we know nothing more than that her armies were forced to retreat with loss. But the subsequent invasion and conquests of Darius extended the knowledge of the Europeans to the modern provinces of Lahore and Moultan, commonly called the Punjaub, or the country watered by the five head branches of the Indus. Herodotus describes the climate of the country as intensely hot; the inhabitants in some points as little better than barbarians; and with a small grain of truth he mixes the strangest and most absurd fables. He mentions the populousness and wealth of the country, and the staple produce of cotton growing wild on trees; also the story of the white ants turning up the earth and digging up gold, which has been copied by succeeding writers; and, finally, the region of the five rivers as bounded by a barren plain, which must no doubt be the sandy desert that lies between the valley of the Indus and the Ganges. The Scythians or Tartars who wandered over the northern and eastern plains of Asia were only known by their irruptions into Europe. The two tribes of the Massagetæ and the Sacæ, the former inhabiting the desert plains to the east of the Aral and north of the Jaxartes, and the latter the country to the north-west of India, are mentioned by Herodotus and other ancient writers; and their description is merely a detail of pastoral manners. The expedition of Alexander into India was a great step in the progress of Asiatic geography. This warlike prince was intent not merely on conquest, but on the diffusion of arts, commerce, and science; and, like some modern conquerors, his army was accompanied by a body of men of science, who were instructed to measure each day the distance traversed, to make an accurate table of the various routes, and to observe and describe the countries through which they passed. Science thus followed in the train of arms; and it was by a European army that the remote regions of the East were first explored. Alexander pursuing his victorious march through Asia Minor, passed the limits of European discovery, and entered the eastern country of Bactriana in pursuit of the Persian army. Having passed the Paropamisan range of the Himalaya Mountains, crossed the Oxus, and taken Maracanda, the modern Samarcand, he advanced northward to the Jaxartes, where he pursued the Scythian host into the northern deserts to the eastward of the Aral. Retracing his steps, he again crossed the Paropamisan Mountains, and advancing eastward among hostile tribes, through the modern country of Cabul or Afghanistan, to the south of the Hindoo Coosh range, he crossed the Indus near the mountains, and having defeated the Indian army of Porus, he obtained the command of the country watered by the five tributary streams of the Indus, where his course was arrested by the murmurs of his troops, who refused to follow him across the desert to the Ganges. Still intent on discovery as well as on conquest, he fitted out a large fleet, and sailing down the Indus to its mouth, in the Indian Ocean, he instructed his admiral, Nearchus, to return to Persia by sea, while he took his course through the modern country of Mekran, and was nearly lost with his whole army in its sandy deserts. Nearchus directed his course along the shores of Asia, and triumphing over the perils of unknown seas, arrived safely in the Persian Gulf, which he ascended to the mouth of the Tigris. This is the first great voyage of discovery of which we have any authentic account; and considering the age of the world in which it was accomplished, it must be viewed as a singular display of courage and of nautical skill. Alexander was not equally successful in tracing the connection of the Red Sea with the Indian Ocean, which remained unknown until the reign of the Ptolemies in Egypt.

Seleucus, the successor of Alexander, carried his arms into India for the purpose of completing its conquest; but he does not appear to have reached the valley of the Ganges. He sent, however, to the court of Sandracottus, an Indian prince who reigned over all the countries from Delhi to the mouth of the Ganges, his ambassador Megasthenes, who acquired the most important and clear information respecting those unknown regions. He visited the celebrated city of Palibothra, the site of which has so much perplexed modern geographers; and, with some admixture of fable, he accurately describes the countries on the Ganges, and their productions; the amazing size of the rivers; the most remarkable animals which he saw, among others the Bengal tiger; and the manners of the people, and their division into castes, with other singular customs.

During the reign of the Ptolemies in Egypt the geography of Asia was still farther illustrated, not by conquest, but by commerce. Alexandria was at that time the great emporium of the eastern trade; and India was explored in its most remote parts, for the precious commodities which it was supposed to produce. The Egyptian mariners entering the Indian Ocean from the Red Sea, and coasting along the Arabian shore, stretched across the Persian Gulf by the help of the south-west monsoon, to the mouth of the Indus, whence they sailed southward along the Malabar coast, and doubling Cape Comorin, extended their voyage on the coast of Coromandel as far as the modern city of Masulipatam.

In the age of Ptolemy the geographer, which was a century later, the knowledge of the Europeans had extended eastward beyond the Ganges to the Burman empire and the Gulf of Siam, though it does not appear that the navigators of antiquity ever reached the Chinese coast. The commerce of India was carried on by land as well as by sea; and regular caravans commenced their route from Byzantium eastward through Asia Minor and Persia, passing through the modern cities of Hamadan and Herat; and journeying northward, and crossing the Oxus and the modern country of Buckharia, they passed the great branch of the Himalaya Mountains which runs northward from the main range under the modern appellation of Beloor Taugh; and descending into the lower plains of Little Thibet, they assembled in great numbers, and, after halting for some time, took their journey to the capital of Serica or China, which occupied a period of seven months. The description given of the Seres as a frugal and mercantile people, averse to all intercourse with strangers, and carrying on their trade at a single station on the frontier, answers entirely to the modern character of the Chinese. The commerce, which during the flourishing era of Rome was carried on between Europe and the eastern parts of Asia, was interrupted by the inroads of the barbarous nations who assailed, and in the end overthrew, the Roman empire; and all knowledge of Asia was for a time lost. It was not till the 6th or 7th century, during the reign of the caliphs at Bagdad, that the Arabian geographers acquired a knowledge of those countries. During this period the country to the west of the Beloor Taugh Mountains, which stretch northward nearly to the frontier of Siberia, consisting of extensive plains, watered by the Oxus and the Jaxartes, was well known to them; and they were imperfectly acquainted with the southern plains of Asia inhabited by the Tartars, though they were as usual the subject of fables. The eastern countries of Hindostan, the beautiful region of Cashmere, the great Asiatic plains, and China, with the island of Sumatra and others, were known to the Arabian geographers, though they seem to have had no correct knowledge of the Asiatic shores. Their accurate description of Chinese manners leaves no doubt of their having reach-

ed that country. The invasion of the Holy Land by the crusaders tended, among its other consequences, to introduce into Europe a knowledge of those countries in Asia which were famed for wealth and the remains of ancient refinement; and from the camps of the crusading kings, as well as from the pope, some remarkable embassies were sent to the Tartar sovereigns, the descendants of the conqueror Zinghis, the site of whose capital of Karrakorum is now the subject of dispute, though it is generally agreed that it must have been situated far east, in the wilds of Tartary. The object of the embassies dispatched by the pope to the Tartar camp was to divert the storm of barbarian invasion from Europe. The ambassadors were friars, who were carried to the head-quarters of the Tartars, in the eastern wilds of Asia, through countries which had never been explored by any European. Rubruquis, a friar, who was sent ambassador by St Louis to the Tartars, has given a lively and circumstantial account of his adventures. He reached the Tartar capital of Karrakorum after a fatiguing and dangerous journey of more than two months, having traversed a vast tract of unknown country, and brought to the knowledge of the Europeans the immense plains and high lands of Central Asia, Eastern Tartary or the country of the Mongols, Thibet, and Cathay or China, and the eastern shores of the continent. All those countries were afterwards visited by the celebrated Venetian traveller Marco Polo, who, being dazzled by the splendid accounts diffused through Europe of the wealth and luxury of Asia, was inflamed with the desire of exploring those distant countries. He accordingly proceeded through Asia Minor, Persia, the high country of Balk, visited the cities of Cashgar and Yarkund, and skirting the great desert of Shamo or Cobi, he reached the Tartar capital of Karrakorum, and finally entered the Chinese empire, of which his account is circumstantial and correct, and of which some of the magnificent cities, though they have fallen from their ancient importance, are still recognised in his accurate description. He returned to Venice by sea after an absence of twenty-four years, having obtained accounts of the eastern islands of Java, Sumatra, Ceylon, and of Ormus in the Persian Gulf, at that time the great and splendid emporium of the Indian trade. The discovery, in 1498, of the passage to India by the Cape of Good Hope, opened the Indian seas to the European fleets; and shortly after this great event, the southern, and partly also the eastern shores of Asia, were completely explored, as well as that great archipelago which extends from the Malacca peninsula to New Holland. In the interior of the continent the progress of discovery was much slower, and only kept pace with the gradual extension of the Russian dominion over the barbarous tribes in Northern Asia. The Tartars under Tamerlane in 1382 had invaded the east of Europe, had taken Moscow, and overrun all the countries on the Volga and the Dnieper. The rise of the northern empire was for more than two centuries obstructed by the inroads of the barbarians; and it was only after long and obstinate struggles that they yielded to the superiority of the Russian arms. About the middle of the 16th century Russia had extended her conquests to the Obi, and her empire was enlarged northward and eastward, until it reached the frontiers of China and the Pacific Ocean. The general form of the continent, which was exhibited in the maps from mere conjecture, was in this manner laid open to Europeans; and in the course of the last century the eastern and northern shores were surveyed; also Kamtschatka, the Kurile Islands, and Jesso. The islands of Japan had been previously discovered by navigators. The relative limits of the Asiatic and American continents were traced by Behring, Tschirikoff, and other navigators, who also discovered the Aleutian or Fox Islands; and finally by Captain Cook, who advancing into Behring's Straits as far as the parallel of 70° 44′, ascertained the near approach and true bearing of the two continents.

The interior countries of Asia near the Caspian and Aral Seas have been visited by Russian travellers, who have corrected some errors of long standing in Asiatic geography. Lake Aral was either unknown to the ancients, or they confounded it with the Caspian Sea, of which they supposed it to form a part, and to be the receptacle of the great river Oxus. After the fact of two separate seas was fully known, the Oxus was still supposed to terminate in Lake Aral; and its course was laid down accordingly in all the most approved charts. The Russians having visited those countries, ascertained by actual observation that the Oxus, as well as the Jaxartes, terminates in the Caspian Sea.

Eastern Asia, namely, the Chinese empire, with the source and termination of all its great rivers; the northern country of the Tartars; the course of the great river Amour; with the high lands of Central Asia, namely, Mongolia, the original seat of the Mongols, were in the course of the 16th and 17th centuries explored by the Romish missionaries, as well as by mercantile travellers. In 1624 Antonio d'Andrada, a jesuit, travelled from the coast of the Great Mogul to China. He passed through the country of Serinagur, and ascending the great Himalaya range, he and his companions endured such incredible hardships that he was forced to return. He afterwards crossed these mountains along with a caravan, and was among the earliest travellers who reached the country of Thibet, which he describes, and also the manners and religion of the people. In 1603 the missionary Goez set out from Lahore, where he resided at the Mogul court on his way to China. He travelled westward, and crossing the Indus, passed through the countries of Cabul or Afghanistan, Cashgar to the north, and the country on the banks of the Oxus; and crossing a ridge of the Himalaya Mountains, he arrived at Yarkund. From this place he journeyed with a caravan across the central country of Mongolia to China. These missionaries were received into high favour by the Chinese emperors, who valued them on account of their science, and gave them access to the public archives, which contained all the Chinese surveys of the empire and of the adjacent countries. By the help of these they exhibited with accuracy the interior geography of Thibet, and also of that extensive country beyond the Ganges which now forms the Burman empire, and which is watered by the great rivers that take their rise in the central mountains and run southward,—the Irrawaddy into the Indian Ocean, the Setang into the Gulf of Martaban, of which it forms the estuary, the Saluen into the same gulf, the Menam into the Gulf of Siam, and the Menam-Kong or the Mekong into the Chinese Sea.[1] These missionaries prosecuted with equal activity and zeal their inquiries into the interior geography of China;[2] they traced the great rivers the Hoangho or Yellow River, and the Yank-tse-Kiang or Blue River, to their termination as well as to their source, which they found to be in the depths of the central moun-

[1] See Crauford's *Journal of an Embassy to the Courts of Siam and Cochin-China.* Geographers are not agreed on the respective appellations of these rivers: in this we have been guided by Mr Crauford.

[2] For a more detailed account of these missionary travels the reader is referred to Hakluyt's *Collection of Voyages;* Purchas' *Pilgrims; Histoire Générale des Voyages*, Paris, 1749; and to the *Historical Account of Discoveries and Travels in Asia*, by H. Murray, who has given an equally learned, judicious, and comprehensive abstract of all the existing information on the subject of Asiatic geography.

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tains, and not in the imaginary lake of Cayamay, as had been generally believed. Grueber, who set out on his travels to the East in 1656, traversed the whole country of China, partly by land and partly by water; and his route to Europe was through the Tartar deserts to Lassa, a town in Thibet, and thence through the mountainous country of Nepaul to Battana on the Ganges, Benares, and finally to Agra, which he reached after a journey of more than twelve months. Other journeys equally enterprising were also undertaken by the missionaries. Desideri set out in 1714 from Delhi, and travelled across the Himalaya Mountains through Cashmere into Thibet; and, at a later period, Horace de la Penna, with a body of twelve missionaries, resided in the same country for a number of years. The missionary Gerbillon, who was in great favour at the Chinese court, travelled in 1688 through the Tartar deserts, with a Chinese embassy, to the banks of the Selingha, there to settle with the Russians the respective limits of the two empires; and having been also in the practice of following the emperor in his hunting expeditions into Tartary, he contributed with other travellers to illustrate the geography of these countries and the manners of the people.

The great extension of the British conquests in Northern India has laid open to Europeans all that portion of Asia which lies on the southern declivity of the Himalaya Mountains, which is interesting not only from its natural grandeur, but also as it contains the sources of the Indus, the Ganges, and the Brahmapootra. The Europeans were indebted for all the knowledge which they possessed of those countries to the Chinese missionaries, who represented the Ganges to rise on the north of the Himalaya chain, from two small streams which pass the town of Ladak. They fixed the source of the Indus in the Beloor Mountains, one of the cross ridges which run north and south from the main Himalaya ridge. The British in India, with all their characteristic ardour in the cause of science, have corrected those errors of the Chinese geographers, having ascertained the source of the Ganges to be not on the north, but on the southern side of the Himalaya Mountains. The extent and bearing, and the vast elevation, of many of the highest peaks of this northern barrier of Hindostan, have also been fixed by the accurate observations of Lieutenant Webb and other officers. From the embassy of Elphinstone into Afghanistan we have received more full details of that country; and the course westward of the great Himalaya chain has been accurately traced, as well as the upper course of the Indus, though the source of that river is still imperfectly known. The missions of Turner into Bootan, of Kirkpatrick and Buchanan into Nepaul, and the embassy of Major Symes and Dr Buchanan to the court of Ava, and of Mr Crauford, who resided in the character of ambassador at that court, and whose works have thrown great light on the commerce and manners of Asia, have contributed materially to illustrate the geography of those countries. Of the vast regions of Tartary to the west of China, and under its dominion, we know nothing except from the earlier travellers and missionaries, and from the accounts published of the journeys of the Russian embassies through these countries; nor is there any immediate prospect of reaching those central districts from the south; for though the inhabitants appear mild and friendly, the Chinese authorities are firm in repressing the slightest intrusion of strangers into the sacred territory.

Asiatic commerce.

Asia, notwithstanding the wars by which it has been desolated, was from an early period the seat of commerce and of wealth. The eastern countries of Hindostan and China appear to have preceded Europe in civilization and industry, and, independent of that diversity of natural productions which is the foundation of trade, they had cultivated many arts and manufactures which were unknown in the western world. Asia accordingly abounded in many precious commodities which could not be produced by the ruder industry of Europe. Thus China had its silk and porcelain; Hindostan its muslins, cotton, precious stones, and aromatics of all sorts; costus, bdellium, spikenard, ivory, tortoise-shell, pepper, &c. These were in general demand throughout Europe, where they could not be produced; and they were procured in exchange chiefly for bullion, which then, as in later times, was the great article of export to India; also for woollen cloths, wine, brass, lead and tin, glass, coral, female slaves, &c., all which commodities met with a ready sale in the markets of Hindostan. The staple commodity of China was silk; and the mode of producing this esteemed luxury being unknown in Europe, it was brought in large quantities, either by the caravans or by the annual fleets, to Alexandria, at that time the great commercial mart of the East, and was thence sent to supply the demand at Rome, where it sold at one time for its weight in gold; but, owing to the high profit, caravans began to travel so regularly to China, that the supply increased with the demand, and the price was reduced. Between the 6th and the 7th centuries Eastern Asia was robbed of this precious monopoly by the art of two Persian monks, who contrived, in a hollow cane, to transport the eggs of the silk-worm from China to Europe, where they were hatched by means of heat, and the race quickly propagated; and one great link of commerce between China and Europe was in this manner broken. The trade of Asia was interrupted by the irruption of the barbarians, who invaded and finally subverted the Roman empire; but the moment the storm was past, commerce resumed its quiet course. Constantinople, the eastern capital of the empire, was still the centre of luxury and trade; as were also such parts of the Roman territory as had not been swept by barbarian invasion; and with those places the caravans still traded, shaping their course as they best could to avoid the distractions of the interior. Farther to the east the caliphs who reigned at Bagdad encouraged science, commerce, and the arts; and the extensive country through which the Oxus and the Jaxartes flowed was the seat of a flourishing commerce and of many opulent cities. Besides Buckharia, still a great city, Balk, Samarcand, Cosh, and others in the valley of the Oxus and the Jaxartes, numerous splendid cities are enumerated which are scarcely known to Europeans. To the east of the great range of mountains which takes a direction from the main Himalaya ridge, the country of Cashgar contained Cashgar its capital, and Khoten, which were both large, populous, and wealthy. Those countries served as the connecting link between India and Europe, and the resting-place of the caravans, which there collected in great force, and prepared for their journey to China across the great eastern desert, or for a more southerly course through the country of Thibet. The armies of Zinghis Khan in the 13th, and of Tamerlane in the beginning of the 15th century, laid waste this highly cultivated and flourishing region. But those conquerors were not the enemies of commerce, and the surplus produce of India still reached Europe, though by a route rendered more difficult and dangerous from the desolation of the intervening countries. But the effect produced on the trade of Asia in the East by the encroachments of barbarism, and by the disorders in the interior, was more than counterbalanced by the growing civilization of Europe. About the beginning of the 14th century, the darkness which had so long covered the western world began to dispel, and the Italian cities of Venice, Genoa, and others, had already made advances in letters, science, and commerce. The costly articles of Asia, her rich stuffs and

precious aromatics, were now required to answer the growing demands of luxury and wealth; and the produce of India, imported into Alexandria through the Red Sea, was thence brought into Italy by the nobles of Venice and Genoa, who were all engaged in trade, and was diffused in smaller quantities all over Europe. The Italian states were enriched by this lucrative traffic, which only ceased with the discovery of the maritime route to India by the Cape of Good Hope. From this period the trade between Asia and Europe took a different direction. The commodities of India and China were transported to Europe directly by sea; and neither Alexandria nor the other ports of the Red Sea or of Italy were any longer the depositaries of the eastern trade. The Portuguese, always distinguished by their ardour for maritime discovery, were the first adventurers in the Asiatic seas. In the course of the 16th century the English and Dutch appeared as their competitors; and with the growing wealth of those countries the trade to the East rapidly increased. The commerce of Asia may therefore be distinguished into the following branches:—1*st*, The inland trade of China, Hindostan, Burmah, &c. with Turkey, the eastern countries of Europe, and with the intervening countries of Persia, Balk, Buckharia, and the regions of the Oxus; also, by a different route, the trade with Russia and the north of Asia. 2*dly*, The maritime trade, including the coasting trade and the trade to the eastern archipelago, and the great trade to Europe and America, in which, from the progress of wealth and luxury, there is a great consumption of Asiatic produce.

Inland commerce.

The inland trade of Asia is carried on by caravans, or large bodies of merchants, who travel together for the sake of security through those parts of the country which are disturbed by predatory tribes. It is only from the southern countries of Asia, such as Hindostan, China, the Burmese countries, Thibet, and the western countries of Persia, Afghanistan, Buckharia, and the regions of the Oxus and the Jaxartes, that Europe can derive any supply of valuable commodities; and all this trade, from whatever quarter it comes, must flow in its progress to Europe through the countries that lie between the Persian Gulf and the Caspian Sea; as the caravans could not, without inconvenience and danger from wandering tribes, pass to the north of this sea or the sea of Aral; and accordingly, though an annual caravan is sent from Astracan to Khyvah and the countries on the Oxus, the chief trade with Russia is by sea to the port of Mangalshuck, and thence to Khyvah and Buckharia. The Russians have also begun to trade with Persia from the Caucasian province of Georgia, of which Tiflis, the capital, has, from a wretched collection of wooden huts, been rapidly improved, under the protecting influence of a European government, into a respectable and wealthy town, the future emporium, as may be anticipated, of this growing trade. The caravans from Constantinople and Syria proceed through Asia Minor and the northern or southern provinces of Persia, according as their ulterior route is through Afghanistan and the Punjaub into Hindostan, or to Thibet and China, or the more northern districts of Balk, Buckharia, and the country of the Oxus and the Jaxartes. Buckharia, though reduced to desolation by Zinghis Khan, is still one of the largest towns of the East, and is only exceeded by Peking and other Chinese cities, or by Calcutta. It is also a great commercial mart; and the caravans which come from the west, passing along the southern shore of the Caspian Sea through the Persian province of Astrabad, a most luxuriant and fertile country, arrive successively at Balfroosh, Ashruff, Astrabad, Mushed, Serrukhs, Merve, formerly the capital of the Seljook sovereigns, but now surrounded by deserts, and at Buckharia. From this great centre of commerce they proceed north-eastward about 400 or 500 miles to Khojend and Kokaun, the former a large city, said to contain 30,000 houses; and crossing the Beloor range of the Himalaya Mountains, they arrive in the Mahometan states of Kashgar and Yarkund, 600 miles east of Kokaun, passing some towns on the way, of which Ush is the most important, being a trading and populous town. Those two latter states lie within the precincts of the Chinese authority, where the most exact order is enforced; and they are fertile, rich, and well cultivated. The town of Cashgar is said to contain 20,000 houses, and to be thronged with strangers from all parts of Asia. Yarkund is also wealthy and populous. So strict a police is maintained by the Chinese authority, that, according to the information given to Fraser,[1] a single traveller may traverse the whole territory as safely as a large caravan. From Kashgar there is a constant intercourse through Chinese Tartary, along the edge of the great central desert, with China, though we know little of the intervening countries beyond what we learn from the accounts of the early missionaries. Besides this eastern trade, and the trade westward along the southern shore of the Caspian, two caravans, consisting of 4000 or 5000 camels each, proceed to Astracan by Khyvah, round the northern shore of the Caspian Sea. The imports from Russia into Buckharia are iron, steel, copper, brass, quicksilver, vermillion, coral, hardware, plated goods, gold and silver embroidery, copper-wire; furs, the broad cloths and cotton manufactured goods of Britain, Germany, and France; refined sugar, cochineal, paper, and a variety of rich goods, which, from this great commercial depot, are diffused far and wide over Central Asia. Russia receives in exchange black lamb-skins, certain manufactures of cotton and silk imported from Persia, antique gems and coins, lapis lazuli, rubies, and turquoises, which are received from the southern country of Buducksha, where there are famous mines of these precious stones. From Cashgar, Yarkund, and the side of China, Buckharia receives large quantities of tea, the great modern staple of the China trade, porcelain and China ware, and the various manufactures of China; and in return sends turquoises, coral, sheep, lamb, and fox-skins, and furs, &c. From Persia shawls are imported, and woollen goods from Kerman; silk stuffs from the cities of Yezd and Ispahan; gold and silver embroidery, copper-ware, loaf, candy, and raw sugar; Hamadan leather; and turquoises, of which there are mines in Persia; and, in return, black sheep and lamb-skins are sent, which are in great request, to be manufactured into black caps; camblet made of camel's hair, coarse coloured silk handkerchiefs, lapis lazuli, indigo from India, cochineal, tobacco, chintzes from Masulipatam, and cotton manufactures. Slaves form a staple article in the commerce of Buckharia, and also of Khyvah. These are made prisoners by the disorderly tribes of Asia, the Koords, Turkomans, &c., in the course of the wars in which they are constantly engaged; and they are carried to the great slave markets of Buckharia and Khyvah, where they are exposed for sale like cattle. The balance of trade is always in favour of Buckharia. Money is consequently in great plenty, and cannot be imported with a profit into this trading city. The Russian caravans, as they journey round the north shore of the Caspian Sea, are frequently attacked by the Kirgeesh and Cossack tribes, and prisoners

[1] *Narrative of a Journey into Khorassan*, Appendix.

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are carried off and sold into slavery. Fraser was assured that the number of Persian slaves in Khyvah and its dependencies exceeded the male population of these countries, and amounted to 150,000; and that, according to inquiries set on foot by the empress Catherine, there were in Buckharia no less than 60,000 Russian slaves.

The commerce of the west with the southern countries of Asia, namely, Cabul or Afghanistan, Cashmere, and India, passes through Persia by a different and more southerly route, namely, by Cashan, Yezd, which is the seat of rich silk manufactures, a great entrepôt of commerce, and a convenient resting place for all the caravans, both from the east and other quarters; through Furrah, and Herat, on the frontiers of Persia, famed for its rich manufactures of silk stuffs, a great channel of communication between the east and the west, and also an entrepôt of all the richest productions from Cabul, Cashmere, and India on the one side, and from Buckharia, Persia, Arabia, Turkey, and even Europe, on the other. From Herat the route continues through Furrah and across the river Helmund and the ranges of the Paropamisan Mountains, to Candahar, a journey of about 800 miles; thence to Cabul, Peshawer, and the countries on the Indus, and across extensive sandy deserts to the rich valley of the Ganges, whence, by this river, there is an easy access to Bengal and to Central India. There are various other routes by which the commerce of Asia, concentrated within the comparatively narrow boundaries of the Caspian Sea and the Persian Gulf, diverges in its progress eastward to the north, as well as to the south. From Buckharia there is a mountainous route into Little Thibet, and thence through Thibet into China; besides other more sequestered and difficult roads, through glens and mountains, where the only mode of transport is on the backs of asses and mules.

Persia, from its central situation between the east and the west, is not only a great entrepôt of Asiatic trade, but, though on the whole rather a poor country, it still contributes some valuable productions to the commerce of the East. It has long been famed for its abundant produce of raw silk, of cotton, and of wool, that of the province of Kerman especially being so valuable for shawls that it rivals in some respects that of Cashmere; of fruits, turquoises, tobacco, grain, &c. Almost all the principal towns of Persia, such as Kashan, Ispahan, Yezd, Tabreez, Kerman, Herat, &c. excel in the manufacture of silks, cottons, woollens, fine carpets, &c.; Kerman also in the manufacture of shawls; and others in that of cutlery, arms, &c. These are its chief exports to other countries, in exchange for their manufactures or produce. To India Persia sends raw silk, carpets, Kerman shawls, dried fruits, tobacco, horses, in which there is a considerable traffic, swords, &c. and specie to make up the deficient balance. The imports from India are cotton goods, as chintzes, sent from Masulipatam by sea to Bushire, whence they reach the interior of Persia, and are thence carried eastward into Cabul and the countries on the Indus; the same article from Moultan, Lucknow, Delhi, &c.; some muslins, indigo, spices, sugar, and sugar-candy, in large quantities; gold and silver stuffs and brocades from Benares; precious stones, Cashmere shawls, iron, lead, copper, &c. Many of these articles, namely, Cashmere shawls, spices, indigo, muslins, &c. are carried through Asia Minor by a long land carriage to their final destination in European Turkey, and are found, along with the lamb-skins of the no less distant Buckharia, in the bazaars of Bagdad and Constantinople.[1] To those countries Persia exports also every article of her own rude and manufactured produce; coarse fabrics, both of silk and cotton, for the consumption of Asia Minor; and many heavy articles, such as grain, rice, tobacco, salt, coffee, cotton, &c.; besides fine silks, brocades, and prints, which are exchanged in Turkey for European goods brought through the countries of the Levant, namely, broad and narrow cloths, cassimeres, cotton goods, chintzes, muslins, veils, silks, satins, French brocades and embroidered goods, imitation shawls, cutlery of all sorts, glass, &c., and a considerable quantity of gold and silver bullion. Persia imports coffee and pearls from Arabia, in exchange for wheat, dried fruits, and cloaks. The mountainous country of Afghanistan, on the southern declivity of the Himalaya ridge, and the country on the head streams of the Indus, export to India horses and ponies bred in Tartary, furs, shawls, Moultan chintz, madder, assafœtida, tobacco, and dried and other fruits, such as almonds and pistachio nuts. The imports from India are coarse cotton cloths, worn by the common people of this country, and also in Tartary; muslins and other fine manufactures, silken cloth and brocade, indigo in great quantities, ivory, chalk, bamboos, wax, tin, sandal wood, almost all the sugar which is used in the country, and spices from the Malabar coast, through Koratchee and other parts of Sinde, and thence to Cabul and Candahar. The Indian cloths, shawls, chintzes, and also the indigo, are exported to Buckharia, from which are imported the broad cloths, cutlery, and hardware of Europe, received from the Russians, and finally consumed in Cabul and the countries of the Indus, loaded with the expenses of a land journey across nearly half the globe.

In the east of Asia, China has from the earliest times been the seat of wealth and of an extensive trade. The Chinese have been always noted for their industrious habits, and the country has from time immemorial abounded in the most valuable produce and manufactures. These were sent westward in the caravans to Asia Minor and into Europe, or they were transported by sea to India, and carried thence by the European fleets to the Red Sea. The same commerce is still continued, and China exports its produce of woollens, silk, and satin; tea in small boxes of thin lead; china, porcelain, raw silk, cochineal, crystal, gold dust, golden ingots, and silver with the Chinese stamp. These are sent through Chinese Tartary into the countries on the Oxus, and also to Cashmere, Cabul, and the countries situated on the southern declivity of the Himalaya Mountains. Regular caravans of horses and ponies, no other animal being fit to travel through those mountainous districts, set out from Cashmere, and from Peshawer, the capital of the Afghan country of Cabul, and a considerable commercial resort, to make their way through Chinese Tartary with goods imported from India and Persia. China carries on also an interior trade to a considerable extent with Russia by the frontier town of Maimatchin, in which European goods and furs are received in exchange for tea, silk, and other articles of Chinese produce and manufacture.

Maritime commerce.

In addition to her internal trade, Asia maintains an extensive intercourse by sea with Europe, America, and with Egypt and all the countries on the Mediterranean. A great trade is also carried on from Hindostan and China to the Asiatic archipelago, and the trade of the Asiatic islands with each other is of great importance. It appears that those islands were at a very early period the seat of commerce; and the learned researches of Europeans have brought to light, in some of them, the monuments of ancient

[1] Elphinstone's *Cabul;* Kinneir's *Geographical Memoir of Persia;* Fraser's *Travels in the Persian Provinces around the Caspian Sea,* Appendix, p. 364.

civilization. Sumatra was the seat of the Malay empire, Java of a Hindoo state; and the Celebes were inhabited by the Bugis, a race of expert navigators and merchants. The productions of these islands, and of the Moluccas and Borneo, namely, spices, aromatics, and gold, entered into the commerce of the ancient world, and were imported into Rome through Egypt. In later times, about the 9th century, the Asiatic archipelago was visited by the Arabs and the Chinese, while the adventurous Malays frequented the coasts of Asia, and even of Africa, and particularly the African island of Madagascar. When these islands were visited by Europeans, about the 15th century, Malacca, Acheen, and Bantam were the great marts of the eastern archipelago, where the rich produce of Sumatra, Borneo, and the Moluccas, conveyed in the small trading craft of the country, was exchanged for that of India and China. The Portuguese fixed on Goa, on the Malabar coast, as the capital of their eastern settlements; and they afterwards selected Malacca as a central station for protecting and extending their intercourse with the neighbouring nations. The Dutch chose Bantam, and afterwards Batavia, situated midway between Hindostan and China, as the centre of their commercial settlements. The situation was most advantageous, and the port was soon frequented by vessels from China and Japan, Tonquin, Malacca, Cochin-China, and the island of Celebes. But the great and flourishing trade of Java was crushed under the colonial monopoly of the Dutch, and under what Sir Stamford Raffles terms "the short-sighted tyranny of a mercantile administration." The conquest of Java by the British in 1812 put an end to this thraldom, and the great trade of the Asiatic archipelago began to centre in Batavia, which was fast rising into a great commercial emporium; all the articles which were the exclusive produce of the eastern islands being collected at its principal ports for re-exportation to India, China, and Europe. Since Java was restored to the Dutch, the free port of Singapore, established by the British, is the centre of a great trade, and is frequented by the Chinese in their junks, and by all the other navigators of those seas with the produce of their respective islands.[1] The Chinese take back with them the nests of a certain species of bird, which are esteemed a great luxury at their tables, and sell, it is said, for their weight in silver; biche-de-mer or tripang, a dried sea-slug, also used in Chinese dishes; Malayan camphor, the exclusive produce of Sumatra and Borneo; the tin of Banca, the spices of the Moluccas, opium, indigo imported from Hindostan; gold and silver, the first collected in Sumatra, Borneo, and some of the other islands. The maritime country trade of the Asiatic islands is carried on chiefly by the Chinese in their junks and brigs, by the Arabs in square-rigged vessels, and by the Bugis, the inhabitants of Celebes, who are all bold and expert navigators.

From the east the annual fleet of Chinese junks arrives with the favourable monsoon among these islands, from Canton, Amoi, and other provinces, with cargoes of teas, raw silk, silk, piece-goods, and innumerable minor articles, for the use of the Chinese, who are settled in great numbers here, and are distinguished by their shrewd, intelligent, and industrious habits. The Chinese extend their voyages to Sumatra, the Straits of Malacca, and eastward as far as the Moluccas and Timor, collecting edible bird-nests, biche-de-mer, and other articles of which Java is the great entrepôt. Java is also a great depôt of European goods; and the people being rather industrious cultivators of their fertile island than mariners or traders, it exports rice, a variety of vetches, salt, oil, tobacco, timber, brass-wire, and its own cloths, and a considerable quantity of European, Indian, and Chinese goods, in exchange for gold dust, diamonds, camphor, benjamin, and other drugs; edible bird-nests, biche-de-mer, rattans, bees-wax, tortoise-shell, and dyeing woods from Borneo and Sumatra. The rice and other productions of Java are exchanged for spices and pungent oils of the Moluccas, and for the tin of Banca. The natives of Celebes are famed for the manufacture of a particular speeies of fine cloths, of a very strong texture, which are in great request, and, along with spices, wax, and sandal-wood, are exchanged for the produce of Sumatra, Borneo, and Java, whence they are exported to China. The Bugis have a large share of the carrying trade of the Asiatic archipelago; and they bring the produce of the Moluccas, and of Borneo and Sumatra, to Java and the other islands, and receive in exchange tobacco, rice, and salt, from Java, besides opium, iron, steel, European chintzes, and broad cloths and Indian piece goods, with which they return eastward during the southwest monsoon.[2]

The eastern countries of Asia, viz. India and China, as we have already stated, have from time immemorial been famed for certain manufactures, such as silks, cambrics, muslins, &c., as well as for other products peculiar to the climate, viz. spices, precious aromatics, medicinal herbs, &c. These were always in great demand in Europe, while the produce of Europe was not wanted in Asia. From the rude state of industry among the western nations, they had nothing to offer in exchange for the finer manufactures of India, and still less could the soil of Europe yield any equivalent for the more genial produce of eastern climes. Hence the great article of export in those times from Europe to Asia was always bullion, the instrument of exchange all over the world. Bullion could only be procured by an exportation of European produce or manufactures at such low prices as to insure a sale; and the loss on such transactions must have been made up to the merchant by the high price of Asiatic goods. The ancient monopoly of silk secured to Asia a favourable balance of trade with Europe, bullion being the only article with which it could be purchased. Notwithstanding the introduction of the silk manufacture into Europe about the 6th or 7th century, the commercial pre-eminence of Asia still continued, and bullion was the chief article of export to the East. Throughout the interior of Asia this superiority remains to the present day; and a continual stream of bullion flows from the Bosphorus eastward through Asia Minor and Persia into Hindostan, and is finally dispersed in the great ocean of the Chinese currency. Bullion is also the principal article sent from Arabia to India in exchange for Indian goods.

But a great revolution has taken place in the trade between Asia and Europe, and especially with Great Britain. Europe is now in a condition to offer an equivalent in manufactures for the produce of Asia; goods of various kinds are sent in exchange for those of India; and from Great Britain remittances in bullion have nearly ceased. So prodigiously has the price of goods been lowered by the use of machinery, that the cotton wool of India is now imported into Britain, and, after being manufactured, is re-exported to the place of its growth, and sold at a lower price than the same goods from the loom of the Indian workman, though it is loaded with the expense of a double voyage across half the globe. The goods of the Eu-

[1] Minutes of Evidence before Select Committee on the affairs of the East India Company, March 1830.
[2] Raffles' *History of Java*; Marsden's *Sumatra*.

ropean manufacturers are poured into Asia through all its seaports, and reaching the interior on the backs of mules and asses, often after a journey of several thousand miles over deserts and mountains covered with perpetual snow, they are sold cheaper than the same articles by the native workmen. The woollen manufactures of Yorkshire, the cotton goods of Manchester and Glasgow, French cloths, and German linens, are dispersed all over Hindostan, and even partially in China; they are found in the bazaars of Buckharia, Samarcand, and Cashgar, and are carried eastward by the caravans into the wilds of Tartary.[1] The accounts laid before the House of Commons of our exports and imports to and from India and China from 1814 to 1828, exhibit a falling off in the importation of Indian manufactures, and a proportional increase in that of the raw materials, such as silk, cotton, indigo, &c. From India and China the annual value of the imports amounts to about L.10,000,000. In 1829 they amounted in value to L.10,627,441; of which the sum of L.8,561,345 is made up of four articles, viz. cotton wool, indigo, raw silk, and tea.[2] The value of the cotton manufactures exported, which amounted in 1814 to L.11,341, had increased in 1828 to L.754,098. The natural productions of Asia, namely, spices, rich aromatics, dyes, and other rare luxuries of tropical climates, will always be in demand in Europe; and the monopoly of tea by the Chinese gives them the command of the European markets. Tea has now almost become one of the necessaries of life, and it travels for a market across half the globe. It is the great commercial link between Europe and China, from which, like the precious produce of silk in ancient times, it can only be procured. But the improved industry of Europe supplies, as already observed, an equivalent in woollen and cotton goods for this highly prized luxury; and there can be no doubt that if the trade were not obstructed by the East India Company's monopoly, it would gradually extend with the growing demand of the Chinese market. The charter of the East India Company expires in 1834; and if the trade is thrown open, it is certain that British produce will make its way into all the most distant markets of the East. Such an intercourse would not only benefit commerce, but would promote the higher interests of civilization, as it would extend to the benighted countries of Asia the literature and science, and all the other improvements, of Europe.

Asia Minor is the most western portion of the great continent of Asia, bounded by the Black Sea on the north, by the river Euphrates on the east, and on the west by the Mediterranean, the Sea of Marmora, and the Straits of the Hellespont and Bosphorus. It is of an irregularly oblong figure, about 1000 miles in length from east to west, and between 400 and 500 in breadth from north to south. The whole country is under the Turkish government; and it is divided into several provinces, of which Natolia and Caramania are the most important. The country is inhabited by Turkish Mahometans, and Christians of various sects and denominations. For other particulars see the preceding article. (F.)

ASIARCHÆ (termed by St Paul, *Chief of Asia*, Acts xix. 31) were the Pagan pontiffs of Asia, chosen to superintend and have the care of the public games, which they did at their own expense; for which reason they were always the richest and most considerable men of the community.

ASINARA, an island of Italy, on the western coast of Sardinia. Long. 8. 30. E. Lat. 41. 0. N.

ASINIUS Pollio, a Roman consul and orator, distinguished himself under Augustus by his exploits and his literary works. He is frequently mentioned with praise by Horace and Virgil, and is said to have collected the first library at Rome. He died at Frescati, at eighty years of age.

ASISIO, or Asito, a city of the pope's territories in Italy, situated about 16 miles east of Perugia. Long. 13. 35. E. Lat. 43. 0. N.

ASKEATON, a post town of Ireland, in the county of Limerick, on the river Deal, near its junction with the Shannon. Population 1239. 144 miles S. W. from Dublin.

ASKEREN, a place five miles from Doncaster, noted for a medicinal spring of a strongly sulphureous nature; it is also slightly impregnated with a purging salt.

ASKRIG, a town in the North Riding of Yorkshire. Long. 0. 5. W. Lat. 53. 50. N.

ASLANI, in *Commerce*, a silver coin, worth from 115 to 120 aspers.

ASMONEUS, or Assamoneus, the father of Simon, and chief of the Asmoneans, a family that reigned over the Jews 126 years.

ASNA, or Esna, a town in Upper Egypt, seated upon the Nile, and occupying the site of the ancient Latopolis. It is near the cataracts of the Nile, and is the last place of any magnitude on the side of Nubia. It contains several monuments of antiquity, and among the rest an ancient Egyptian temple, pretty entire, all painted throughout, except in some places that are effaced by time. The columns are full of hieroglyphic figures. This structure is considered by Denon as one of the most perfect monuments of ancient architecture he had seen. A little way from thence are the ruins of an ancient nunnery, said to be built by St Helena, surrounded with tombs. Asna is the principal town in these parts, and the inhabitants are rich in corn and cattle. They drive a considerable trade into Lower Egypt and Nubia, by means of the Nile, and also by the caravans that pass over the desert. The inhabitants are all Arabs, except about 200 Copts, the ancient inhabitants, and a sort of Christians. They are under the government of the Turks, who have a cadi; and the Arabs have two sherifs of their own nation. Long. 32. 35. E. Lat. 23. 15. N.

ASOLA, a town of the territory of Brescia, in the Austrian division of Italy. It is built on the river Chiese, about 20 miles south-east from Brescia, and contains a population of 3100 persons. Long. 10. 35. E. Lat. 45. 6. 4. N.

ASOLO, a town of Austrian Italy, in the delegation of Verona, on the river Musone. It is well built and finely situated. It has a cathedral and several other churches, with an ancient castle, and the remains of a Roman aqueduct. The inhabitants are mostly employed in cultivating silk. Long. 12. 1. 5. E. Lat. 45. 47. 37. N.

ASOPH, a town of Cuban Tartary, in Asia, seated on the river Don, near its mouth, a little to the east of the Palus Mæotis or Sea of Asoph. Long. 39. 5. E. Lat. 47. 18. N.

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[1] Mr J. Burnes, surgeon to the residency at Booj, who has lately published an interesting *Narrative of a Visit to the Court of Sinde*, mentions that the princes and nobles are clothed in British manufactures. He resided at Hyderabad in 1827.

[2] See Papers relating to the Finances of India and China, printed by order of the House of Commons, February 1830.

ASP, in *Natural History*, a small poisonous kind of serpent. It is said to be thus denominated from the Greek ασπις, *a shield*, in regard to the manner of its lying convolved in a circle, in the centre of which is the head, which it exerts or raises like the umbo or umbilicus of a buckler. This species of serpent is very frequently mentioned by authors, but so carelessly described that it is not easy to determine which, if any, of the species known at present may properly be called by this name. It was with the asp that Cleopatra is said to have dispatched herself, and prevented the designs of Augustus, who intended to have carried her captive to adorn his triumphal entry into Rome. But the fact is contested: Sir Thomas Brown places it in the list of vulgar errors. The indications of that queen's having used the ministry of the asp were only two almost insensible pricks found in her arm; and Plutarch says that the cause of her death is unknown. Lord Bacon makes the asp the least painful of all the instruments of death. He supposes it to have an affinity to opium, but to be less disagreeable in its operation. See Reptilia.

ASPASIA of Miletus, a celebrated courtezan who settled at Athens under the administration of Pericles. She was of admirable beauty: yet her wit and eloquence, still more than her beauty, gained her extraordinary reputation among all ranks in the republic. Her conversation was so entertaining and instructive, that notwithstanding the dishonourable commerce she carried on in female virtue, persons of the first distinction, male and female, resorted to her house as to an academy. It is said that she even numbered Socrates among her hearers. She captivated Pericles in such a manner that he dismissed his own wife in order to espouse her; and by her universal knowledge, irresistible elocution, and intriguing genius, she in a great measure influenced the administration of Athens. She was accused of having excited, from motives of personal resentment, the war of Peloponnesus. The companions of Aspasia served as models for painting and statuary, and themes for poetry and panegyric. Nor were they merely the objects, but, as is said, the authors, of some literary works, in which they established rules for the behaviour of their lovers, particularly at table; and explained the art of gaining the heart and captivating the affections.

ASPASTICUM (from ασπαζομαι, *I salute*), among ecclesiastical writers, a place or apartment adjoining to the ancient churches, wherein the bishop and presbyters sat, to receive the salutations of the persons who came to visit them, desire their blessing, or consult them on business. This is also called *aspasticum diaconicum*, *receptorium*, *metatorium*, or *mesatorium*, and *salutatorium*; in English, *greeting-house*.

ASPER, in *Grammar*, an accent peculiar to the Greek language, marked thus (ʻ), and importing that the letters over which it is placed ought to be strongly aspirated, or pronounced as if an *h* were joined with them.

Asper, or *Aspre*, in *Commerce*, a Turkish coin, three of which make a medine.

ASPERIFOLIATE, or Asperifolious, among botanists, such plants as are rough-leaved, having their leaves placed alternately on their stalks, and a monopetalous flower divided into five parts.

ASPEROSA, a town of Turkey in Europe, situated on the coast of the Archipelago. It is a bishop's see. Long. 25. 20. E. Lat. 40. 58. N.

ASPHALTITES, or Lake of Bitumen, so called from the bitumen which floats upon its surface, and equally well known under the name of the Dead Sea, a name associated with many fables, and derived from a long standing belief that no creature could live in its waters, or within the reach of its pestiferous exhalations. Asphaltites.

Very different accounts have been given of the dimensions and other properties of this lake, by the ancient writers Diodorus, Pliny, Strabo, and Josephus. These accounts have, however, been corrected by modern travellers, although, from the difficulty of approaching it, their information is not so full or accurate as might be desired. Pliny estimates it to be 100 miles in length by 25 in breadth. Josephus reckons the length, from the mouth of the Jordan to the town of Segor, 66 miles, and the breadth 15 miles. This agrees with the estimate of modern travellers, which is 60 or 70 miles in length and from 10 to 20 in breadth. Carne, in his *Letters from the East*, estimates the length at 60 miles, and the breadth at from 8 to 10. It is about 180 miles in circuit. In form it is curved like a bow, and placed between two ranges of mountains, bold and craggy, and of the most majestic appearance, by which it is sheltered, so that when the wind is blowing all around it is perfectly calm like a sheet of lead. But the grandeur of its features is blended with an air of sadness and desolation, and all travellers have been struck with the death-like stillness of its waters, which seem to accord well with its mysterious character and name. This lake has been seldom visited, owing to the wild Arabs who inhabit the country, and who rob and murder without mercy the defenceless traveller. Mr Buckingham, who had only a distant view of it, mentions that the inhabitants who live within 15 miles distance of its shores have no information respecting it, and believe in all the wonderful tales and superstitions which are circulated of its marvellous properties. It was since visited by Mr Carne, whose Letters contain a lively picture of eastern scenery and manners; and his representation of the death-like stillness of this lake and the adjacent country agrees with that of all former travellers. "There was not," he observes, when he visited it, "a breath of wind; and the waters lay dead on the shore. Whoever has seen the Dead Sea will have its aspect impressed on his memory. It is in truth a gloomy and fearful spectacle. The precipices in general descend abruptly into the lake, and on account of their height it is seldom agitated by the winds. Its shores are not visited by any footstep save that of the wild Arab, and he holds it in superstitious dread. On some parts of the rocks there is a thick sulphureous incrustation, which appears foreign to their substance; and in their steep descents there are several deep caverns, where the benighted Bedouin sometimes finds a home." The same writer observes, that though the sun shone full on the bosom of the lake, and though it had the appearance of a plain of burnished gold, yet "the sadness of the grave was on it and around it, and the silence also. However vivid the feelings are on arriving on its shores, they subside after a time into languor and uneasiness; and you long, if it were possible, to see a tempest wake on its bosom, to give sound and life to the scene."[1]

The lake Asphaltites receives the waters of the river Jordan, and other brooks and springs from the adjacent mountains, yet never overflows, though it has no visible outlet for those copious supplies. This fact seems to have embarrassed some naturalists, who, in order to account for it, have had recourse to the hypothesis of a secret communication with the Mediterranean. But it has been demonstrated by accurate calculation, that evapora-

[1] *Letters from the East*, by J. Carne.

Asphaltites.

tion is more than sufficient to carry off the waters brought by the river. Under the influence of a dry and hot climate, it is in fact very considerable, and frequently becomes sensible to the eye by the fogs with which the lake is covered at the rising of the sun, and which are afterwards dispersed by the heat. To the north it has the plain of Jericho, and to the south extends, on both sides of the Jordan, the great plain, which is open, and stretches beyond the reach of the eye. It is this plain of which, according to Mr Buckingham, Josephus gives so accurate a description.

This lake is supposed to occupy the site of the cities of Sodom and Gomorrah, destroyed by fire, as is recorded in the sacred volume, for their unparalleled iniquities; and the strange properties ascribed to its waters, and other marvellous stories connected with it, seem to have a reference to this awful tradition. It was at one time supposed that no living creature could exist in its waters—that they exhaled such a poisonous effluvia that the birds of the air died in attempting to fly over it. The apples that were said to grow on its shores, fair without, but full of ashes and bitterness within, were also supposed to contain some moral or illustration of its ancient story; and it was affirmed that the ruins of the five cities which were destroyed by fire were still seen at the bottom of the lake in clear weather. Josephus mentions that a constant smoke was seen to arise from its surface. Almost all these stories have been exploded by the testimony of modern travellers, although some of them have an obvious foundation in the physical properties of the waters. Their taste is remarkably bitter, saline, and pungent; and hence has arisen the notion of its pestiferous vapours and deadly influence. We are told even by Volney, that its waters are destructive both of animal and vegetable life; but he denies that its vapours have any deadly quality, for swallows, he says, are often seen to skim its surface without injury. M. de Chateaubriand, who visited its shores in 1807, with an imagination abundantly disposed to the marvellous, has given the first decided testimony that it abounds in fish. He reached the lake when it was already dark, and passed the night among some Arab tents. "About midnight," says he, "I heard a noise upon the lake, and was told by the Bethlehemites who accompanied me, that it proceeded from *legions of small fish* which come out and leap about on the shore." This interesting traveller speaks in the following terms of its saline properties:—"The first thing I did on alighting was to walk into the lake up to my knees, and to taste the water. I found it impossible to keep it in my mouth. It far exceeds that of the sea in saltness, and produces upon the lips the effect of a strong solution of alum. Before my boots were completely dry, they were covered with salt; our clothes, our hats, our hands, were in less than three hours impregnated with this mineral."

The common story, that nothing will sink in it, is to be ascribed to the extraordinary density of its waters. Bodies follow the general law, and sink or swim, according to the proportion of their gravity to the gravity of the water of the lake; but its specific gravity is such that a man may lie upon its surface motionless, without danger of sinking. This effect was experienced by Pococke, and by a Scotish traveller, Mr Gordon of Clunie, who also bathed in it. This gentleman brought home a phial of its water, and Dr Marcet found its specific gravity to be 1·211; "a degree of density," says he, "not to be met with in any other natural water." Dr Marcet was employed to analyse Mr Gordon's specimen, which that gentleman had presented to Sir Joseph Bankes in 1807; and the whole process, with its results, is detailed in the *Philosophical Transactions* for that year. It was found that 100 grains of the water contains the following substances, in the under-mentioned proportions:—

Asphaltum.

	Grains.
Muriate of lime	3·920
Muriate of magnesia	10·246
Muriate of soda	10·360
Sulphate of lime	0·054
	24·580

The water of the Dead Sea had been previously analysed by Messrs Macquer, Lavoisier, and Sage, of whose experiments an account was published in the *Mémoires de l'Academie des Sciences* for the year 1778. Their analysis afforded results greatly different from those obtained by Dr Marcet, which that gentleman ascribes to some inaccuracy in their mode of operating. We find, however, that the processes employed by Dr Marcet have been called in question, and the accuracy of his proportions denied, by a very skilful chemist, who subsequently instituted an analysis of the Dead Sea water. We allude to Klaproth, who procured a specimen brought from the East by the Abbé Mariti, and whose analysis offered the following proportions:—

Muriate of magnesia	24·20
Muriate of lime	10·60
Muriate of soda	7·80
	42·60
Water	57·40
	100

Klaproth also found the specific gravity to be 1·245 instead of 1·211; agreeing in this respect more nearly with Macquer and Lavoisier, who stated it at 1·240. The specific gravity of Dr Marcet's specimen may, however, have been less from its having been taken from the lake not far from the influx of the Jordan, on which account it might be somewhat diluted.

Dr Clarke mentions that the inhabitants of the country still regard the Dead Sea with feelings of terror. This may be owing to the tradition that its waters cover the engulphed cities of Sodom and Gomorrah, or to the ideas entertained of the peculiar insalubrity of its exhalations. It is much to be regretted that this traveller was prevented by the Arabs, who infested the neighbourhood, from exploring the lake, which he only saw at some distance; as, with his attainments, he could not have failed to gather some interesting information regarding its natural history. Though M. de Chateaubriand, a few years after, succeeded in reaching its banks, he could only, owing to the same cause, remain a few hours; and besides, however capable of interesting his readers, he was not so well qualified for accurate or scientific observation. While some of his facts run counter to the ancient fables, others seem calculated to add to the list; as, when he discovers a resemblance between the noise of its waves and the stifled clamours of the people whom they engulfed. (See Chateaubriand's *Travels in Greece, Palestine, Egypt, and Barbary;* Dr Clarke's *Travels in Greece, Egypt, and the Holy Land; Philosophical Transactions of the Royal Society of London for* 1807; Klaproth, *Beiträge zur Chemischen Kenntnis der Mineral Körper*, book v. p. 185, Berlin, 1810; Buckingham's *Travels in Palestine;* Carne's *Letters from the East.*)

ASPHALTUM, Bitumen Judaicum, or Jew's Pitch, is a light, solid bitumen, of a dusky colour on the outside, and a deep shining black within; of very little taste, and having scarcely any smell, unless heated, when it emits a strong pitchy one. It is found in a soft or liquid state on the surface of the Dead Sea, and by age grows dry

and hard. The same kind of bitumen is met with likewise in the earth in other places of the world, in China, America, and in some places of Europe, as the Carpathian Hills, France, Neufchatel, &c.

ASPHURELATA are semi-metallic fossils, fusible by fire, and not malleable in their purest state, being in their native state intimately mixed with sulphur and other adventitious matter, and reduced to what are called *ores*.

ASPICUETA, or AZPILCUETA, MARTIN DE, commonly called the Doctor of Navarre, was descended of a noble family, and born on the 13th of December 1491, at Varasayn, a small city of Navarre, not far from Pampeluna. He entered very young into the monastery of regular canons at Roncevaux, where he took the habit, which he continued to wear after he left the convent. He studied classical learning, natural and moral philosophy, and divinity, at Alcala in New Castile, adopting chiefly the system of Petrus Lombardus, commonly called the *Master of the Sentences*. He applied himself to the study of the law at Ferrara, and taught it with applause at Toulouse and Cahors. After being first professor of canon law at Salamanca for 14 years, he quitted that place to be professor of law at Coimbra, with a larger salary. The duties of this office he discharged for the space of 20 years, and then resigned it to retire into his own country. Pope Pius V. made him assistant to Cardinal Francis Aciat, his vice-penitentiary; and Gregory XIII. never passed his door without calling for him, and stopped sometimes a whole hour to talk with him in the street. He was consulted as an oracle; and his name became so famous, that even in his lifetime the highest encomium on a learned man was to call him a *Navarrus*. He died on the 21st June 1586, having by temperance prolonged his life to the age of 94. He wrote a number of treatises on morality, law, &c. These were published in 3 vols. folio in 1589, and in 6 vols. 4to in 1602.

ASS, in *Zoology*. See MAMMALIA.

ASSAI, in *Music*, signifies quick; and, according to others, that the motion of the piece be kept in a middle degree of quickness or slowness. As, *assai allegro, assai presto*.

ASSAM, a kingdom of Asia, situated on the north-west of Bengal, between the 25th and 26th degrees of north latitude, and extending from 94 to 99 degrees of east longitude. The exact limits, however, are not precisely ascertained; for this country is very little known to Europeans, and what respects its extent to the east is at present to be understood as partly conjectural. Assam is an immense valley, about 700 miles in length by between 60 and 80 in breadth, surrounded by high hills on all sides, and interspersed with numerous eminences in the interior, and universally susceptible of cultivation. The whole superficies is calculated at 60,000 square miles, a large portion of which is occupied by woods and rivers, and the remainder consists chiefly of fertile soil; but this calculation is exclusive of any conquered countries, and of the territories that extend in every line beyond the hills. Part of the kingdom is mountainous, particularly what is called Higher or Upper Assam; and part of it is low and level, containing extensive plains, subject to frequent inundations in the rainy seasons. The general position of this great valley, as well as of the mountains and rivers traversing it, is in a direction from north to south. It is bounded on the north by the successive ranges of the mountains of Bootan, Anka, Duffala, and Miree; and on the south by the Garrow Mountains, which rise higher as they recede northward, and change their name to Naga at a place called Coliabark. Probably the rivers intersecting Assam are more numerous than those of any other country of equal extent in the universe, from its being completely environed by hills. The rains are collected together, and, pouring down in irresistible torrents, swell the waters below, until the plains are covered by the inundation. The valley is divided throughout by the Brahmaputra into two parts nearly equal; and many islands, some of them very large, are formed by it and by the confluence and mutual intersection of other rivers. They contribute alike to fertilize the ground and to facilitate the intercourse of the inhabitants, as they are navigable by flat-bottomed boats, capable of transporting them and their property. Of these rivers, not less than sixty-one are known and distinguished by particular names, of which thirty-four flow from the northern, and twenty-four from the southern mountains; but the source of the Brahmaputra is scarcely yet ascertained, nor were Europeans acquainted with its course until it was traced by Major Rennell. However, it seems to rise beyond the confines of Assam. As the rivers change their names at different places, it is sometimes difficult to discover which is meant in the description; and their sizes may be estimated differently, according as they are examined in the time of inundation, or otherwise. Many of them are remarkable for a long and winding course. The Dhekow or Degoo, by the size of which geographers are accustomed to compare the other rivers, rises very far to the eastward of the Naga Mountains, which it traverses for a considerable distance, and then winds 200 miles through the valley from its entrance, until it joins the Dehingh, a great branch of the Brahmaputra. Another river, the Dekrungh, rises in the Duffala Mountains, and, exhibiting a large stream, occupies 100 miles in its windings before falling into the Brahmaputra, though the direct line does not exceed 25. Notwithstanding its depth and rapidity, it is navigable by small boats. The river Pisola, which likewise rises in the Duffala Mountains, pursues a winding course of 60 miles, and, during the rainy season, may be ascended to the base of the mountains; but it is not navigable after the inundations subside. The rivers to the south are never so rapid, as the inundations commence from the northern rivers. Both these and the Brahmaputra are filled, so that the water has no considerable current until May or June, when the current is rather stronger from the south in the season of the rains, though the increase is not very material, as the large river at this period is always pretty full, and checks the rapidity of all the southern rivers.

Among the numerous islands of different dimensions formed by the intersection and confluence of the rivers, is Majuli, or the Great Island, as it is called by pre-eminence, which appears to constitute one of the chief political divisions of the kingdom. This island extends 100 miles in length by about 60 in breadth, and is formed by the river Dehingh on the west and the Looicheh on the north; but, independently of these great aquatic boundaries, it is intersected by numerous streams, so that it in fact consists of a cluster of lesser islands, and some islets besides, near the banks, which in the principal rivers are dry only while no inundations prevail. The other islands throughout Assam are of all different dimensions, from the most inconsiderable size to six, ten, or twenty miles and more in length. A correct picture of the country may thus be figured as being an extensive valley, environed by mountains, and full of rivers and level plains. While the rivers constitute its defence, promote the convenience of its inhabitants, and contribute to fertilize the soil overflowed by their inundations, they interrupt occasional intercourse from their magnitude and rapidity; and it is to be observed that there is only one stone-bridge in the kingdom, which was erected at Rungpore by workmen brought from Bengal. Besides the Great Island, or

Majuli, Assam contains other two political divisions, Ootrecole, Uttarcul, or Ootreparah; and Deccancole, Dacshincul, or Deccanparah; the former of which, Ootrecole, denotes the country lying north of the Brahmaputra; the latter, Deccancole, that to the south. And it is farther to be remarked, that Majuli is formed by great arms of the same river, though passing by different names.

The political subdivisions of Assam are apparently almost as numerous as the more important natural ones; but the province of Camroop in Ootrecole is one of the largest, and the best known by description, at least to Europeans. It formerly gave name to an extensive kingdom, of which the capital seems to have been Rangmattee, beyond the present western confines of Assam. It now stretches about 100 miles in length; and its breadth, from the banks of the Brahmaputra to the foot of the mountains, is 40 miles. There are no strong places within its limits, and its chief town is Cotta. The district of Summooria occupies the southern banks of the Brahmaputra; and the district of Nodooaria, which extends to the eastward, is divided into nine shares or districts, held by so many rajahs, though under the rule of only two.

Valuable minerals are found in Assam: the whole country produces gold in abundance, insomuch that from 12,000 to 20,000 of the inhabitants are said to have been constantly employed in collecting it. This precious metal is found in all the rivers flowing from the northern mountains, but it differs in purity and colour, and also in malleability. That which is obtained in the Dekrungh is particularly celebrated, and is distinguished by a higher colour than that found in the Brahmaputra and other rivers. Gold is more abundant in the bed of the Brahmaputra than in the channel of most of the others, but is considered inferior in colour and quality. What is procured from the bed of the Burrowgown is esteemed as much superior even to the gold of the Dekrungh; the colour is deeper and more vivid, and is compared by the natives to fire; it is likewise deemed of more intrinsic value, and always bears a greater price in Assam. The greatest quantities of gold are found nearest the mountains, which probably indicates that it is carried down from them by the torrents; but it is never sought in the beds of the southern rivers. In the others, as those flowing from the north, it is of a paler colour, less pure, and in smaller quantity, according as it is recovered from the mines farther to the east. The persons employed in collecting it pay a small tribute to the sovereign in proportion to their success. Besides this precious metal, there are mines of silver, lead, and iron, which all belong to the king, and are wrought for his advantage alone. Rock-salt is dug out of the earth, but it is bitter, and of indifferent quality. The vegetable products of Assam are abundant, and of excellent quality: thick and extensive forests cover a large portion of the country; cultivated fields, especially of rice, the staple grain for subsistence, and the finest fruits, are generally to be seen. A Persian writer, Mahommed Cazim, in describing this country, makes some observations on its general appearance, which, as he was hostile to the inhabitants, may probably merit the greater confidence. He speaks of Majuli as "an island well inhabited, and in an excellent state of agriculture: it contains a spacious, clear, and pleasant country, extending to the distance of about 100 miles. The cultivated part is bounded by a thick forest, which harbours elephants, and where these animals may be caught, as well as in four or five other forests of Assam. If there be occasion for them, five or six hundred elephants may be procured in a year. Across the Dhonec, which is the side of Ghergong, is a wide, agreeable, level country, that delights the heart of the beholder. The whole face of it is marked with population and tillage; and it presents on every side charming prospects of ploughed fields, harvests, gardens, and groves. From the village of Salagerah to the city of Ghergong, a space of about 100 miles is filled with such an uninterrupted range of gardens, plentifully stocked with fruit-trees, that it appears as one garden. Within them are the houses of peasants, and a beautiful assemblage of coloured and fragrant herbs, and of garden and wild flowers blowing together. As the country is overflowed in the rainy season, a high and broad causeway has been raised for the convenience of travellers, from Salagerah to Ghergong, which is the only uncultivated ground that is to be seen. Each side of this road is planted with shady bamboos, the tops of which meet and are entwined. Among the fruits which this country produces are mangoes, plantains, jacks, oranges, citrons, limes, and punialeh, a species of amleh, which has such an excellent flavour that every person who tastes it prefers it to the plum. There are also cocoa-nut trees, pepper, vines, areca-trees, and the sadij (an aromatic leaf), in great plenty. Sugar-cane excels in softness and sweetness, and is of three colours, black, red, and white; there is ginger free from fibres, and betel-vines. The strength of vegetation and fertility of the soil is such, that whatever seed is sown, or slips planted, they always thrive. The environs of Ghergong furnish small apricots, yams, and pomegranates; but as these are wild, and not assisted by cultivation and engrafting, they are very indifferent. The principal crop of this country consists in rice and mash. Ades, a kind of pea, is very scarce, and wheat and barley are never sown." This is a favourable picture of the kingdom; and although the revolutions and convulsions which it has since undergone may have affected the industry of the inhabitants, the means of renewing it remain.

Elephants, wild buffaloes, hogs, and tigers, haunt the banks of the rivers, which are covered with grass and reeds so as to be impenetrable by men. It has been affirmed that there are neither horses, asses, nor camels here, though two species of the first are natives of a neighbouring territory. The other animals are unknown, but the rivers abound so plentifully with fish as to afford a copious supply to the inhabitants. A particular kind of animal, different from the common silk-worm, according to Turpin, produces silk of another texture, with which beautiful dresses, but of bad quality, are fabricated.

It is not unlikely that some external physical distinctions prevail among the natives, according as they inhabit the high or the low countries, and that their moral qualities are influenced by the same cause. Mahommed Cazim remarks, that the complexion of the mountaineers, like that of the inhabitants of all cold climates, is red and white. They are an active, hardy race, well formed; but the noses of the women are flattish. Both sexes go almost naked; formerly the mountaineers were absolutely so; and, unlike the easterns in general, none of the females, even those of the highest rank, are veiled. They wear a blue bonnet or cap, from which hogs' teeth are suspended; which is perhaps of more recent use, as the Persian just referred to says they had neither turbans, robes, drawers, nor shoes. Their most valuable ornaments at present are bracelets of coral or yellow amber, and sometimes tortoise-shell or sea-shells. They dwell in habitations constructed of wood, bamboos, and straw; and there is only an inconsiderable difference between those of the more wealthy and the poorer classes. With regard to their state of civilization, or their manners and customs, we have very little certain information applicable to the present times. Most probably the mountaineers are more barbarous than the inhabitants of the low country and the plains; and as the kingdom is divided into a number of

petty states, those may be subordinate to some paramount authority; but the frequent broils of the rajahs retard the civilization of their subjects. Mahommed Cazim, who entertained a decided aversion to the Assamese, reproaches them with indiscriminately feeding "on all kinds of food, human flesh excepted; they even eat animals that have died a natural death." He divides them into two tribes, Assamians and Cultanians; the latter excelling the former in every thing but warlike operations.

It appears that the government of this kingdom is monarchical, and that a sultan or rajah rules the whole; yet, owing to the incessant contest for power, the course of succession, if it be hereditary, is disturbed, and the most potent chief, gaining an ascendency, restores the country to peace. The government was wont to be mildly administered: in the words of Turpin, the "king was attentive to the happiness of his subjects, and employed none excepting slaves to labour in the mines. It was the only country where humanity was not crushed under the pressure of despotism." Formerly the rajah kept a guard of six or seven thousand warlike troops, whose courage was equal to any enterprise.

The religion of these people is supposed by Mr Hamilton to be Brahminical. It is certain that they have many temples erected to their divinities throughout their territories, although the character and description of these divinities have never been explained. In the time of Aurungzebe they are said to have had no settled faith: They do not adopt any mode of worship practised either by Heathens or Mahometans; nor do they concur with any of the known sects which prevail amongst mankind. But it is by no means credible that all their temples have been erected since that era. Rafts covered with human heads are sometimes seen floating down the Brahmaputra through Bengal, which has excited conjectures that they belonged to victims offered to their sanguinary deities. It is not evident, however, that human sacrifices, unless the destruction of life at funeral obsequies be called such, are publicly offered up in the neighbouring Asiatic territories. This species of barbarity has been widely extended over the world; captives were slaughtered at the pile of the ancients,—slaves were buried alive to serve their masters in the world to come,—and even the chosen wife of her husband's affections has been doomed to destruction at the same moment that his earthly remains were consigned to oblivion. Such customs have been familiar to mankind from the earliest records of time, and, among the rest, were practised by the natives of Assam. On the decease of a rajah, or any distinguished person, a capacious pit was prepared, where not only his own body, but many of his women and attendants, were also buried. Of the latter was a torch-bearer, together with a quantity of oil and lamps, as essential to his comfort in a future state; some of his most elegant and useful furniture, carpets and clothes, were, in like manner, included; and even elephants, together with gold and silver, formed part of the promiscuous assemblage. A strong roof, resting on thick timbers, was then constructed over the pit, and the miserable victims not already slain were left to perish by a lingering death.

In regard to the state of the arts, it is to be inferred that the Assamese are behind many nations in their vicinity. Formerly they manufactured excellent silks, chiefly for home consumption; they likewise fabricated velvet, and embroidered it beautifully with flowers. Perhaps the same is continued, as also the extraction of salt from vegetable substances; and their gunpowder was reputed of the best quality. Nay, the easterns hence ascribed the invention of this destructive substance to their ingenuity, and affirm that it passed from them to Pegu, and thence to China. Their chief exports to Bengal are gold, elephants' teeth, two kinds of lac, which was esteemed the finest in those regions, a coarse raw silk, and coarse cotton cloths. Brandy is made from grapes, afforded by the numerous vines in Assam. Agriculture is certainly well understood: the populousness of several districts which have attracted the attention of the traveller, proves that there is no scarcity of subsistence; and well-frequented fairs are spoken of as being held in different places. Assam contains some celebrated temples, probably of ancient date; and their military causeways, constructed at an early period of their history, are of admirable extent and magnitude. One of these, now in a state of decay, runs from Cooch Bahar in Bengal, through Rangamatty, to the utmost extremity of the eastern limits of the kingdom, serving as a boundary of the Bootan dominions. Another, a work of immense labour, passes the capital; and the banks of the Dhekow are connected with the southern mountains by a lofty rampart, traversing the space of ten or fifteen miles. It is undoubted, that although most authors who have treated of this subject describe these structures as military causeways only, they have served both as the means of communication among the inhabitants during the season of inundations, and as barriers to the overflowing rivers spreading still farther on the plains. Thus the great causeway which approaches the capital was raised to preserve the interior from the inundations of the Dehingh, while in the dry season the river retires two miles from its base.

A great many towns and villages are scattered over the banks of the rivers of Assam, these having been peculiarly selected by the natives for their habitations; and a certain number seems to be included in a circle under the same administration. The capital, which is called Ghergong, Kirgana, or perhaps more properly Gurgown, is situated in 25° 35′ north latitude, 93° 10′ east longitude, at a considerable distance above Rungpore, which is sometimes called the capital, but is only the military station of Ghergong. It stands on the high banks of the river Dhekow or Degoo. This city Dr Wade, who resided ten years in Assam, describes to have been ten miles long by five in breadth; and we learn from other authors that it was fortified and encircled by a fence of bamboos, inclosing villages and fields in its circuit. Like other cities of the East, each house stood separate, amidst a cultivated spot or garden; each side of the river was lined with dwellings, and the royal palace was situated on its banks. It had four gates, constructed of earth and stone, from each of which the palace was distant four miles and a half, by which means its position was nearly in the centre, and close to the Dhekow. This palace was a spacious edifice, apparently between two and three miles in circuit, surrounded by a causeway, planted on each side by a close bamboo hedge, serving instead of a wall, and beyond them a wet ditch, always full of water. The interior contained many apartments, both for state and convenience, elegantly ornamented. Mahommed affirms it as an undoubted fact, that 3000 carpenters and 12,000 labourers were constantly occupied, during two years, in constructing the palace; but an insurrection, which took place about the year 1790, proved almost totally destructive of it and the rest of the city. Rungpore, situated in 25° 47′ north latitude, and 89° 5′ east longitude, stands on the opposite side of the Dhekow, with the river Numdaugh flowing on the south; a rampart or causeway to resist the inundations protects it on the east; and on the west it is secured by a bridge, the only access whereby it can be approached. The circle including it contains several towns, and is about twelve miles in length by ten in breadth. Goahautee is the capital of Lower Assam, and

the residence of a viceroy. The surrounding territory occupies a hilly country on both sides of the Brahmaputra, the hills on each side forming a spacious amphitheatre, which has been fortified equally by nature and art. The district Goahautee is divided into north and south, including several strong passes among the fortified hills. A great number of other towns might be mentioned by name; but, excepting their position, we are unacquainted with any thing regarding them.

The history of this kingdom is involved in great obscurity, arising both from its remote situation, and from a jealousy of strangers, which has almost entirely precluded the access of Europeans; and by a singular fatality, after this difficulty had been conquered by the admission and residence of an intelligent physician, Dr Wade, some of the most important materials collected by him were lost on being transmitted to Europe. The present race of inhabitants is said to have occupied the country during a thousand years, but not by any means in tranquillity; at least we know that, since 1638, they have been involved in frequent contests with their neighbours. In these, however, they have in general been successful, for unconquerable obstacles are opposed to their enemies. "Whenever an invading army has entered their territories, the Assamese have sheltered themselves in strong posts, and have distressed the enemy by stratagems, surprises, and alarms, and by cutting off their provisions. If these means failed, they have declined a battle in the field, but have carried the peasants into the mountains, burnt the grain, and left the country desert. But when the rainy season has set in upon the advancing enemy, they have watched their opportunity to make excursions and vent their rage; the famished invaders have either become their prisoners, or been put to death. In this manner powerful and numerous armies have been sunk in that whirlpool of destruction, and not a soul has escaped." Such dangers were sufficient to intimidate the boldest adventurers, and we have the testimony of eye-witnesses that they are not exaggerated. About the close of the fifteenth century, Husein Shah, king of Bengal, invaded Assam with a formidable force of cavalry, infantry, and also of boats; and, in the outset, was successful. The rajah, unable to meet him in the plains, retired to the mountains, whither Husein could not follow him; but returning to Bengal, he left his son with a large army to keep possession of the country; the rainy season commenced, and the roads were shut up by inundations; then the rajah descended from the mountains, intercepted the supplies of the invaders, harassed them with skirmishes, and cut off the whole in detail. Another prince of Hindostan attempted the conquest of Assam, with an immense force of cavalry; but, says the author who records the enterprise, they were all devoted to oblivion in that country of enchantment, and no intelligence or vestige of them remained. The Assamese, however, in 1638 met with a reverse of fortune in leaving their own confines to sail down the Brahmaputra and assail the inhabitants of Bengal, being repulsed by the troops of Shah Jehaun.

The rajah of Assam had assumed or preserved the title of Sarjee or Swerg, which signifies celestial, and lived in great pomp and splendour in the reign of Aurungzebe, the Mogul emperor, who died in 1707. That great prince, desirous of extending his conquests, sent an army, under an able general, to attempt the subjugation of this kingdom; partly, it would appear, to humble the pride of the rajah, who was so vain-glorious as to believe that his ancestors were of divine origin, and that one of them, inclining to visit the earth, descended by a golden ladder; and partly to disseminate the principles of the Mahometan faith. The army advanced victoriously, conquering all opposition, and gained possession of the capital. There the imperial general, considering himself firmly established, made many regulations for internal administration, and also proclaimed the Mahometan religion. Measures were taken for keeping the roads open, and for supplying the army with provisions; and, as the season was now changing, he resolved, when the inundations subsided, to put his troops in motion to extirpate the rajah and those adherents who had escaped. The conquest of Assam extended to a large portion of the country, for all the villages of Decancole submitted to the invaders, and those of Ootrecole followed; yet it is not to be inferred that this was accomplished without loss; for the panegyrist of the general describes the country as spacious, populous, and hard to be penetrated; that it abounded in dangers; that the paths and roads were beset with difficulties; and that the obstacles to conquest were more than could be expressed. The inhabitants, he says, were enterprising, well armed, and always prepared for battle. They had lofty forts, numerously garrisoned and plentifully provided with warlike stores; and the approach to them was opposed by thick and dangerous jungles and broad and boisterous rivers. Under these circumstances it was wonderful that the army prevailed; "but the Mussulman hordes experienced the comfort of fighting for their religion, and the blessings of it reverted to the sovereignty of his just and pious Majesty." But the Assamese were unsubdued: the climate proved destructive to the Moguls, who were obliged to evacuate the city, and, after being harassed by the natives, to retreat from the country with diminished numbers.

Towards the earlier part of the eighteenth century, it is said that some of the Brahmins of Bengal reached Assam, desirous of introducing their religion there, where the inhabitants still had no settled faith. Amidst their exertions for this great object, they persuaded them that it would be gratifying to their deity, Brahma, if they would use salt imported from Bengal in preference to their own, which it greatly excelled. To this the sovereign consented, on condition that it should be monopolized by himself, and that the vessels conveying it should not penetrate beyond the frontier; and, in consequence, forty vessels, each of from 500 to 600 tons burden, have annually been sent thither.

About the year 1790, the kingdom was in the most distracted state from a widely extended insurrection, followed by the absolute destruction of many important places; and, in the year 1793, a detachment of British troops was sent to aid the restoration of the rajah, who seems to have been dethroned by the insurgents. This detachment gained the capital, and completely effected their object; and the rajah was so sensible of the assistance he had received, that he immediately concluded a commercial treaty very favourable to the British interests. It was probably on this occasion that Dr Wade visited Assam, and that Mr Wood, of the engineers, constructed a map of a considerable portion of the country. Either this or another was transmitted to Britain, we have understood, to be deposited in the Advocates' Library at Edinburgh; but, after its arrival, it unfortunately never reached the place of its destination, which is much to be regretted, since the geography and history of the country are both so little known.

ASSARIUM, in *Antiquity*, denotes a small copper coin, being a part or diminutive of the *as*. The word ασσαριον is used by Suidas indifferently with οβολος and νομισμα, to denote a small piece of money; in which he is followed by Cujacius, who defines ασσαριον by *minimus æris nummus*. We find mention of the assarium in the gospel of St Matthew, chap. x. ver. 29.

ASSARO, a city in the island of Sicily, and intendancy of Calatanissetta, containing 3300 inhabitants. The situation is lofty and healthy, but there is nothing remarkable except a number of caverns in the hills in its neighbourhood.

ASSARON, or Omer, a measure of capacity in use among the Hebrews, containing five pints. It was the measure of manna which God appointed for every Israelite.

ASSASSIN, a person who kills another with the advantage either of an inequality in the weapons, or by means of the situation of the place, or by attacking him at unawares. The word *assassin* is said by some to have been introduced from the Levant, where it took its rise from a certain prince of the family of the *Arsacidæ*, popularly called *Assassins*, living in a castle between Antioch and Damascus, and bringing up a number of young men, ready to pay a blind obedience to his commands; whom he employed in murdering the princes with whom he was at enmity. But according to Mr Volney, the word *Hassassin* (from the root *hass*, to kill, to assassinate, to listen, to surprise), in the vulgar Arabic, signifies *robbers of the night*, persons who *lie in ambush to kill;* and is universally understood in this sense at Cairo and at Syria. Hence it was applied to the *Batenians*, a tribe of Syria, who slew by surprise. This people probably owed their origin to the Carmatians, a famous heretical sect among the Mahometans, who settled in Persia about the year 1090; whence, in process of time, they sent a colony into Syria, where they became possessed of a considerable tract of land among the mountains of Lebanon, extending itself from the neighbourhood of Antioch to Damascus. The first chief and legislator of this remarkable tribe appears to have been Hassan Ben Sabah, a subtle impostor, who by his artifices made fanatical and implicit slaves of his subjects. Their religion was compounded of that of the Magi, the Jews, the Christians, and the Mahometans; but the capital article of their creed was to believe that the Holy Ghost resided in their chief; that his orders proceeded from God himself, and were real declarations of his divine pleasure. To this monarch the orientals gave the name of *Sheikh-el-Jebelz;* but he is better known in Europe by the name of the *Old Man of the Mountain.* This chief, from his residence on Mount Lebanon, like a vindictive deity, with the thunderbolt in his hand, sent inevitable death to all quarters of the world; so that from one end of the earth to the other, caliphs, emperors, sultans, kings, princes, Christians, Mahometans, and Jews, every nation and people, execrated and dreaded his sanguinary power, from the strokes of which there was no security. At the least suggestion or whisper that he had threatened the death of any potentate, all immediately doubled their guards, and took every other precaution in their power. It is known that Philip Augustus, king of France, on a premature advice that the sheikh intended to have him assassinated, instituted a new body-guard of men distinguished for their activity and courage, called *sergens d'armes*, with brass clubs, and bows and arrows; and he himself never appeared without a club, fortified either with iron or gold. Most sovereigns paid secretly a pension to the sheikh, however scandalous and derogatory it might be to the lustre of majesty, for the safety of their persons. The knights-templars alone dared to defy his secret machinations and open force. This people once had, or at least they feigned to have, an intention of embracing the Christian religion. They reigned a long time in Persia and on Mount Lebanon. Holagoo or Hulaku, a leader of the Mogul Tartars, in the year 655 of the Hegira, or 1254 of the Christian era, entered their country and dispossessed them of several places; but it was not till some years after that they were totally extirpated. This achievement was owing to the conduct and intrepidity of the Egyptian forces sent against them by the Sultan Bibars.

A *History of the Assassins*, in the German language, by Mr Von Hammer, was published at Stuttgard in 1818. It contains some new and striking views of the origin, proceedings, and doctrines of the sect. He represents them as forming a military and religious order, subject to the control and direction of a grand master, like the templars, to whom the title of Old Man of the Mountain was applied. We must content ourselves with referring our readers to this learned and curious work.

ASSAULT, in *English Law*, is an offer or attempt to hurt the person of another; as, if one lifts up his cane or his fist in a threatening manner at another, or strikes at him, but misses him, this is an assault; the actual touching of the person not being necessary to make the offence. Finch describes it to be "an unlawful setting upon one's person." No words whatsoever, be they ever so provoking, can amount to an assault. There are, however, opinions to the contrary.

ASSAY, Essay, or Say, in *Metallurgy*, the proof or trial of the goodness, purity, value, &c. of metals and metalline substances. In ancient statutes this is called *touch*, and those who had the care of it *keepers of the touch.*

ASSAYING, taken generally, implies an examination or analysis of any ore or substance whose constituent parts are to be chemically determined. The term, however, more particularly relates to the ascertaining of the qualities of gold and silver in relation to their state of purity; and in the following observations we mean to confine ourselves entirely to this object.

Importance of this art.

In whatever point of view we consider the art of assaying these metals, it cannot fail to appear of great importance to the welfare and prosperity of the civilized world. Every one must be aware of the importance of a metallic currency agreeing in its standard fineness with the decree which establishes its circulation, and that it is an object of the greatest consequence to a nation to have the means of ascertaining with accuracy the value of the coins issued by the authority of the monarch. Since the reign of Henry VIII. we have had no capricious and unjustifiable changes in the standard fineness of our coins. That monarch, as Dr Henry remarks, "after he had squandered all his father's treasures, the grants he had received from parliament, and the great sums he had derived from the dissolution of the religious houses, began to diminish his coins both in weight and fineness. This diminution at first was small, in hopes, perhaps, that it would not be perceived: but after he had got into this fatal career, he proceeded by rapid steps to the most pernicious lengths. In the 36th year of his reign silver money of all the different kinds was coined, which had only one half silver and the other half alloy. He did not even stop here: in the last year of his reign he coined money that had only 4 oz. of silver and 8 oz. of alloy in the pound weight; and the nominal pound of this base money was worth only 9s. $3\frac{3}{4}$d. of our present money. He began to debase his gold coins at the same time, and proceeded by the same degrees. But it would be tedious to follow him in every step. In this degraded and debased condition Henry VIII. left the money of his kingdom to his son and successor Edward VI. This shameful debasement of the money of his kingdom was one of the most imprudent, dishonourable, and pernicious measures of his reign: it was productive of innumerable inconveniences and great perplexity in business of all kinds, and the restoration of it to its standard purity was found to be a work of great difficulty." (Henry's *History of Great Britain*, vol. xii. p. 336 and 337.)

Assaying.

To possess the art, therefore, by which such dishonourable proceedings as are just detailed may be speedily detected, is evidently an object of the greatest utility; inasmuch as the debasement of the coin would require an adjustment of the relative value of commodities to the degraded standard; and the more facility that can be given to this adjustment, the less perplexity and injury will be sustained by the public.

The importance of the art of assaying will further appear when we consider the extent of the manufacture of plate, and ornamental articles of gold and silver, the standard value of which is determined by an assay of a few Troy grains only. The nicety and delicacy of the operation must be great, and much practical experience requisite, to obtain uniformly a satisfactory result.

Description of implements.

The principle of assaying gold and silver is very simple: It consists of two operations—the separation of the alloy from the precious metals, and the parting of these latter from each other.

Before proceeding to the detailed description of these processes, we shall describe the furnaces and implements used in the art of assaying.

Plate LXXVIII. AAAA, fig. 1, is a front elevation of an assay furnace; *aa* a view of one of the two iron rollers on which the furnace rests, and by means of which it is moved forward or backward; *b* the ash-pit; *c c* are the ash-pit dampers, which are moved in a horizontal direction towards each other for regulating the draught of the furnace; *d* the door or opening by which the cupels and assays are introduced into the muffle; *e* a movable funnel or chimney, by which the draught of the furnace is increased.

BBBB, fig. 2, is a perpendicular section of fig. 1; *aa* end view of the rollers; *b* the ash-pit; *c* one of the ash-pit dampers; *d* the grate; *e* the plate upon which the muffle rests, and which is covered with loam nearly one inch thick; *f* the muffle in section representing the situation of the cupels; *g* the mouth-plate, and upon it are laid pieces of charcoal, which during the process are ignited, and heat the air that is allowed to pass over the cupels, and which will be more fully explained in the sequel; *h* the interior of the furnace, exhibiting the fuel.

The total height of the furnace is 2 feet 6½ inches; from the bottom to the grate, 6 inches; the grate, muffle, plate, and bed of loam with which it is covered, 3 inches; from the upper surface of the grate to the commencement of the funnel, *e* fig. 1, 21½ inches; the funnel *e* 6 inches. The square of the furnace which receives the muffle and fuel is 11¾ inches by 15 inches. The external sides of the furnace are made of plates of wrought iron, and are lined with a 2-inch fire-brick.

CCCC, fig. 3, is a horizontal section of the furnace over the grate, showing the width of the mouth-piece or plate of wrought iron, which is 6 inches, and the opening which receives the muffle-plate.

Fig. 4 represents the muffle or pot, which is 12 inches long, 6 inches broad inside; in the clear 6¾: in height 4½ inside measure, and nearly 5½ in the clear.

Fig 5, the muffle-plate, and which is of the same size as the bottom of the muffle.

Fig 6 is a representation of the sliding door of the mouth-plate, as shown at *d* in fig. 1.

Fig. 7, a front view of the mouth-plate or piece, *d* fig. 1.

Fig. 8, a representation of the mode of making, or shutting up with pieces of charcoal, the mouth of the furnace.

Fig. 9, a view of the cupel, which is generally one inch by ⅞ths of an inch.

Fig. 10, the teaser for cleaning the grate.

Fig. 11, a larger teaser, which is introduced at the top of the furnace, for keeping a complete supply of charcoal around the muffle.

Fig. 12, the tongs used for charging the assays into the cupels.

Fig. 13 represents a board of wood used as a register, and is divided into 45 equal compartments, upon which the assays are placed previous to their being introduced into the furnace. When the operation is performed, the cupels are placed in the furnace in situations corresponding to these assays on the board. By these means all confusion is avoided, and without this regularity it would be impossible to preserve the accuracy which the delicate operations of the assayer require.

The furnace and implements which we have just detailed are such as are used in the Royal Mint and Goldsmiths' Hall in the city of London.

We shall now proceed to a description of a small assay furnace invented by Messrs Anfrye and D'Arcet of Paris. They term it *Le Petit Fourneau à Coupelle.* Fig. 14 represents this furnace, and it is composed of a chimney or pipe of wrought iron *a*, and of the furnace B. It is 17½ inches high and 7¼ inches wide. The furnace is formed of three pieces; of a dome A; the body of the furnace B; and the ash-pit C, which is used as the base of the furnace, fig. 14 and 15. The principal piece or body of the furnace B has the form of a hollow tower, or of a hollow cylinder, flattened equally at the two opposite sides, parallel to the axis, in such a manner that the horizontal section is elliptical. The foot which supports it is a hollow truncated cone, flattened in like manner upon the two opposite sides, and having consequently for its basis two ellipses of different diameters; the smallest ought to be equal to that of the furnace, so that the bottom of the latter may exactly fit it. The dome, which forms an arch above the furnace, has also its base elliptical, whilst that of the superior orifice by which the smoke goes out preserves the cylindrical form. The tube of wrought iron is 18 inches long and 2½ inches diameter, having one of its ends a little enlarged and slightly conical, that it may be exactly fitted or jointed upon the upper part of the furnace dome *d*, fig. 14. At the union of the conical and cylindrical parts of the tube there is placed a small gallery of iron *e*, fig. 14, 15, and 16. See also the plan of it, fig. 17. This gallery is both ingenious, useful, and necessary. Upon it are placed the cupels, which are properly heated during the ordinary work of the furnace, that they may be introduced into the muffle when it is brought into its proper degree of heat. A little above this gallery is a door *f*, by which, if thought proper, the charcoal could be introduced into the furnace; and above that there is placed at *g* a key or valve, which is used for regulating the draught of the furnace at pleasure. Messrs Anfrye and D'Arcet say, that, to give the furnace the necessary degree of heat so as to work the assays of gold, the tube must be about 18 inches high above the gallery for annealing or heating the cupels. The circular opening *h*, in the dome, fig. 14, and as seen in the section, fig. 15, is used to introduce the charcoal into the furnace: it is also used to inspect the interior of the furnace, and to arrange the charcoal round the muffle. This opening is kept shut during the working of the furnace, with the mouth-piece, of which the face is seen at *n*, fig. 15.

The section of the furnace, fig. 15, presents several openings: the principal, which is that of the muffle, is placed in *i*; it is shut with the semicircular door *m*, fig. 14, and as seen in the section *m*, fig. 15. In front of this opening is the table or shelf upon which the door of the muffle is made to advance or recede; the letter *q*, fig. 15, shows the face, side, and cross section of the shelf, which makes part of the furnace. Immediately under the shelf is a horizontal slit *l*, which is pierced at the level of the upper part of the grate, and used for the introduction of

the rod of iron, fig. 31, that the grate may be easily kept clean. This opening is shut at pleasure by the wedge represented at *k*, fig. 14 and 15.

Upon the back of the furnace is a horizontal slit *p*, fig. 15, which supports the fire-brick S, fig. 15, and upon which the end of the muffle, if necessary, may rest: *u*, fig. 15, is the opening in the furnace where the muffle is placed.

Fig. 19 is a plan of the grate of the furnace, and fig. 20 a horizontal view of it. These two figures show us the dimensions of the ellipses, and determine the general form of the furnace, and thickness of the grate. To give strength and solidity to the grate, it is encircled by a bar or hoop of iron. We see at *z* the groove in which the hoop of iron is fixed. The holes of the grate are truncated cones, having the greatest base below, that the ashes may more easily fall into the ash-pit. The letter *v*, fig. 15, shows the form of these holes. The grate is supported by a small bank or shelf, making part of the furnace, as seen at *a*, fig. 15.

The ash-pit C has an opening *y* in front, fig. 15, and is shut when necessary by the mouth-piece *r*, fig. 14 and 15.

To give strength and solidity to the furnace, it is bound with hoops of iron at *b*, *b*, *b*, *b*, fig. 14.

Figs. 21, 22, and 23, are views of the muffle.

Fig. 24 is a view of a crucible for annealing gold.

Figs. 25, 26, and 27, are cupels of various sizes to be used in the furnace. They are the same as those used by assayers in their ordinary furnaces.

Figs. 28 and 29 are views of the hand-shovels used for filling the furnace with charcoal; they should be made of such size and form as to fit the opening *h* in figs. 14 and 15.

Fig. 30, the smaller pincers or tongs by which the assays are charged into the cupels, and by which the latter are withdrawn from the furnace.

Fig. 18, the teaser for cleaning the grate of the furnace.

Fig. 16 is a representation of the furnace first constructed by Messrs Anfrye and d'Arcet, and which was worked by means of a pair of bellows, which forced a current of air through the brass tube *b*, entering the ash-pit under the grate at the circular hole *c*, fig. 15. The strength of the blast or current of air can be regulated at pleasure by the stop-cock *d*, fig. 16.

Process of assaying.

We shall now proceed to a description of the process of assaying, as performed by the assayers of the Royal Mint and Goldsmiths' Hall, and shall then state the facility afforded by the furnace of Messrs Anfrye and d'Arcet in conducting this operation upon a smaller scale and reduced expense.

Some preliminary observations may be requisite in regard to the muffle and cupels, to the proportioning of lead in assaying, &c. before the operation of the assay commences.

In the furnace above described, the number of assays that can be made at one time is 45. The same number of cupels are put into the muffle. The furnace is then filled with charcoal to the top, and upon this are laid a few pieces already ignited. In the course of three hours, a little more or less, according to circumstances, the whole is ignited, during which period the muffle, which is made of fire-clay, is gradually heated to redness, and is prevented from cracking, which a less regular or more sudden increase of temperature would not fail to do: the cupels also become properly annealed. All moisture being dispelled, they are in a fit state to receive the piece of silver or gold to be assayed.

The greater care that is exercised in this operation, the less liable is the assayer to accidents from the breaking of the muffle, which it is both expensive and troublesome to fit properly into the furnace.

The cupels used in the assay process are made of the ashes of burnt bones (phosphate of lime). In the Royal Mint the cores of oxhorn are selected for this purpose, and the ashes produced are about four times the expense of the bone-ash used in the process of cupellation upon the large scale. So much depends upon the accuracy of an assay of gold or silver, where a mass of 15 lbs. Troy in the first and 60 lbs. Troy in the second instance is determined by the analysis of a portion not exceeding 20 Troy grains, that every precaution which the longest experience has suggested is used to obtain an accurate result: hence the attention paid to the selection of the most proper materials for making the cupels.

The cupels are formed in a circular mould made of cast steel, very nicely turned, and by which means they are easily freed from the mould when struck. The bone-ash is used moistened with a quantity of water sufficient to make the particles adhere firmly together. The circular mould is filled and pressed level with its surface, after which a pestle or rammer, having its end nicely turned, of a globular or convex shape, and its size equal to the degree of concavity wished to be made in the cupel for the reception of the assay, is placed upon the ashes in the mould, and struck with a hammer until the cupel is properly formed. These cupels are allowed to dry in the air for some time before they are used. If the weather is dry, a fortnight will be sufficient.

The greatest possible attention should be paid to the quality of the lead used in assaying. If it contain silver, it will be easy to perceive a source of material error in the delicate operations of the assayer. Lead revived from litharge contains only about half a grain in the pound weight, and is preferred on that account to lead immediately revived from the ore, which usually contains a larger quantity.

The proportion of lead used in an assay of silver varies according as the external character of the silver to be assayed indicates a comparative state of fineness or coarseness to standard metal; which an expert assayer may pretty accurately determine by the eye: but his opinion will also in some measure be regulated by the comparative ease or difficulty of flattening upon an anvil the piece of silver to be assayed;—if coarse, the metal is harder than standard, and of a brilliant glossy appearance; but if soft and easily flattened, and of a dead white colour, it will indicate a state approaching to purity. The quantity of lead is then proportioned by the opinion of the assayer, and varies from 10 to 20 times the weight of the silver used. It should be observed, that a cupel is capable of absorbing only its own weight of litharge; and attention should accordingly be paid to the size of the cupel, when any silver is to be assayed which requires a great quantity of lead.

As it is always requisite to proportion the lead to the estimated quantity of alloy in the silver before cupellation, the ancient assayers made use of *touch-needles*, which were bars or slips of metal made with pure silver, alloyed with definite proportions of copper in a regularly increasing series, from the least to the greatest proportion which may ever be required. The silver to be assayed was examined in comparison with the touch-needles in colour, tenacity, and other external characters; and its alloy was estimated by that of the needle to which it showed the closest resemblance. These needles are seldom or never used now; and the external character of the metal is sufficient to guide an experienced assayer in the proportioning of the lead to the estimated alloy in the silver which he has to assay.

In Aikin's *Dictionary of Chemistry and Mineralogy*, under the article Assaying, there is a table of the pro-

Assaying. portions of lead to the estimated alloy in fine silver, founded upon the experiments of Messrs Tillet, Hellot, and Macquer, which were the basis of a regulation subsequently adopted by an edict of the late French government. The great uncertainty of the use of the touch-needles probably suggested these experiments to the French chemists; and as this table may be extremely useful to inexperienced assayers, we shall insert it here, together with the observations accompanying it in the above work.

"Copper, the usual alloy of the fine metals, when taken singly, is found to require from ten to fourteen times its weight of lead for complete scorification on the cupel. Now, all admixtures of fine metal tend to protect the copper from the action of the litharge, and the more obstinately, the greater the proportion of fine metal; so that copper with three times its weight of silver (or 9 oz. fine), requires forty times as much lead as copper; with eleven parts of silver it requires seventy-two parts of lead, and the like in an increasing ratio. The following is the table of the proportions of lead required to different alloys of copper, of which a few points are founded on the above-mentioned experiments, and the rest filled up according to the estimated ratio of increase (being multiples of the assay integer 24 in arithmetical progression). In the three first columns is shown the absolute increase of the quantity of lead in alloys of decreasing fineness; in the three last columns will be seen the gradual diminution of the protecting power of fine metal against scorification in proportion to the increase of alloy, shown by the decreasing quantity of lead required for the same weight of copper under different mixtures."

TABLE.

Silver.	Copper.	Lead.	Ratio of Increase.		Copper.	Silver.	Lead.
23 with	1 requires	96	= 4 × 24	and hence	1 with	23 requires	96
22 ...	2	144	= 6 × 24	.....	1 ...	11	72
20 ...	4	192	= 8 × 24	.....	1 ...	5	48
18 ...	6	240	= 10 × 24	.....	1 ...	3	40
16 ...	8	288	= 12 × 24	.....	1 ...	2	36
14 ...	10	336	= 14 × 24	.....	1 ...	$1\frac{2}{5}$	33
12 ...	12	384	= 16 × 24	.....	1 ...	1	32
10 ...	14	432	= 18 × 24	.....	1 ...	$\frac{5}{7}$	30
8 ...	16	480	= 20 × 24	.....	1 ...	$\frac{1}{2}$	30
6 ...	18	528	= 22 × 24	.....	1 ...	$\frac{1}{3}$	29 ×
4 ...	20	576	= 24 × 24	.....	1 ...	$\frac{1}{5}$	28 ×
2 ...	22	624	= 26 × 24	.....	1 ...	$\frac{1}{11}$	28 ×

In the article just referred to, it is remarked that many assayers of good authority use proportions of lead to alloy considerably different from the above table, and that the whole of the numbers here given may be considered as rather high in regard to the quantity of lead. The German assayers, it is added, observe the following rule:

Copper.	*Silver.*	*Lead.*
1 with	30 requires	128
1	15	96
1	7	64
1	4	56
1	3	40
1	1	30
1	$\frac{1}{3}$	20
1	$\frac{1}{13}$	17

In proportioning the lead to the alloy supposed to exist in the silver to be assayed, care must be taken not unnecessarily to increase the quantity; though it would be all oxidated or absorbed by the cupel sooner or later; which is proved by the cupellation of lead *per se*, in order to ascertain the portion of silver it contains; the latter being always found in a globular shape on the cupel and in a state of purity.

In the process of cupellation with lead, however, there is always a loss of silver. Mr Tillet found, by experiments which he made with pure silver and lead, whose retent of silver was known, that after the process of cupellation, the button of silver was never precisely of the same weight as before, but was always a portion lighter, even when the heat of the assay furnace was not sufficient to drive off any of the silver. The conclusion was obvious,—a part of the silver was carried into the cupel by the lead. This was proved by reviving the oxide of lead from the cupel, and cupelling the lead by itself, when the quantity of silver left upon the test was found to be ten times as great as the natural proportion of this metal in the lead, and very nearly corresponded with the loss of silver in the first instance. It will be obvious, then, that the assayer's report of the title or purity of any sample of silver, unless corrected, would make the metal somewhat less pure than it actually is, because all loss is put to the account of alloy. Mr Tillet calculates, when no more lead is used than is necessary for the entire separation of the alloy, that it carries down into the cupel as much silver as, when the whole is again reduced, would make the noble metal $\frac{1}{128}$ of the mass, when the natural admixture of the silver is only about $\frac{1}{1152}$. But if an excess of lead is employed for cupellation, this loss of silver is somewhat greater, though it does not increase in the ratio of the excess of the lead; for 10 parts of lead to a given alloy will not carry down twice as much silver as 5 parts, though the difference of loss will be very sensible.

Assay weights. The weights used in assaying gold and silver are peculiar to the profession. In the assaying of silver a given number of grains are taken, which is called the *assay pound*. This assay pound varies from 14 to 24 grains Troy. This imaginary pound is subdivided into ounces and pennyweights, and the latter into half-pennyweights, which is the lowest term used in reporting assays of silver; so that there are 480 different reports for silver (this being the number of half-pennyweights in the pound); and therefore each nominal half-pennyweight weighs $\frac{1}{20}$ of a Troy grain when the entire assay pound is 24 grains.

The report of an assay of silver is made according to the proportion of pure metal which it is found to contain. The legal standard of Sterling money of silver is 11 oz. and 2 dwts. fine, and 18 dwts. alloy. If an assay of silver was found to contain 11 oz. only of pure silver, it would be reported *worse* 2 dwts., meaning worse than standard silver by 2 dwts. or 48 grains in the pound Troy. If an

assay, on the contrary, contained 11 oz. and 6 dwts. pure silver, it would be reported *better* than standard by 4 dwts. in the pound Troy; because 18 dwts. being the standard proportion of alloy, it was found that it only contained 14 dwts. alloy. When bullion thus assayed and reported is for sale, its value is calculated by reducing the bar or ingot of silver into standard metal.

	lbs. Troy.	oz.
In the first example which we have given, if the ingot of silver assayed weighed.....	50	0
there would be deducted from the weight 2 dwts. per lb. or.....	0	5
which 5 oz. is the excess of alloy above the proportion of 18 dwts. to the 11 oz. 2 dwts. of fine metal, and the bar of silver would be, in standard weight,.....	49	7

	lbs.	oz.
On the contrary, if the ingot weighed.....	50	0
and the alloy were deficient, which is the case when the metal is reported better than standard by 4 dwts. in the pound Troy, there would be added to the 50 lbs. 4 dwts. per pound, which would be equal to.....	0	10
Making the standard weight of the ingot....	50	10

The gold assay pound, which is from 10 to 20 grains Troy, is subdivided into 24 carats, and each carat into 4 assay grains, and each grain into quarters; so that there are 384 separate reports for gold, each equal to 15 Troy grains, or what is termed a quarter carat grain. An accurate assayer, however, can ascertain, in an assay of gold, to 3 grains Troy; but it is the custom of the trade not to report less than a quarter carat, or 15 grains Troy. A substantial reason is given for this rule to justify the practice of it. An ingot of gold generally weighs a journey weight, which is 15 lbs. Troy; from a sample cut from the two opposite ends, weighing from 10 to 20 grains, the value of the mass of 15 lbs. is to be determined: if this ingot had been imperfectly melted, the mass would not be homogeneous, and a difference might exist in it of several Troy grains; and the allowance between the quarters given in the assay report is an indemnity to the purchaser. Indeed, so particular are many in the bullion trade, that they will not purchase any foreign gold bullion until it has been remelted by refiners or melters in whose integrity they repose confidence. This, we believe, is generally the case with the Bank of England in all her purchases of foreign gold bullion.

The assay report of gold is made according as it is better or worse than standard. The standard of our gold coin is 22 carats fine and 2 carats alloy. If, by assay, an ingot of gold was found to contain 21 carats fine gold, it would be reported *worse* 1 carat, the mass containing a carat of alloy more than the proportion of 2 carats to 22 carats fine. If the ingot weighed 15 lbs. Troy, there would be deducted from the gross weight 1 carat, or 240 grains Troy, reducing the standard of the mass to 14 lbs. 11 oz. 10 dwts. If, on the contrary, the mass was found to contain 23 carats fine gold, it would be reported 1 carat *better* than standard; and this carat would be added to the gross weight of the ingot, which we have supposed to weigh 15 lbs. Troy, and would be called 15 lbs. 0 oz. 10 dwts. of standard gold. When the gold assay pound or integer is only 12 grains, the quarter assay grain weighs only $\frac{1}{32}$ part of a Troy grain. This will show how delicate the scales must be by which the assayer works in order to obtain accuracy. In the Royal Mint the scales of the assayers will be sensibly affected even with the $\frac{1}{1000}$th part of a Troy grain.

When the assay pound is subdivided, as for silver, in the same manner as the Troy pound, it is obvious that all the lower denominations bear the same relation to each other, which is some little advantage in transferring the assay reports to real mixtures for use. On the contrary, the carat subdivision for gold is confined to assaying; but its fractions being aliquot parts of the pound Troy, the calculation for real use is very easy. As the pound Troy contains 5760 grains, the carat corresponds with 240 grains or 10 dwts.; the assay grain, or fourth part of a carat, with 60 Troy grains; and the assay quarter-grain with 15 Troy grains; to which report, when the assayer has separated the gold (4 oz. for example), he adds 4 *oz. gold in a pound Troy.* Whereas in gold-parting he takes two equal pieces, treats one as a silver assay and the other as a gold assay, to find the absolute quantity of each metal, after which the report is made on gold singly, to which is added the report of the silver separately. Thus, if he finds 4 oz. of gold, and 3 oz. of silver, he reports *worse* 14 *carats* (2 carats being equivalent to an assay ounce, and consequently the 4 oz. of gold equal to 8 carats, which subtracted from 22 carats, the gold standard, leaves 14), to which report he adds, *fine silver* 3 *oz.* But when the mixed metal contains more than half alloy, it is called *metal for gold and silver*, and the absolute quantity of each is reported separately.

Having made the reader acquainted with these details, we shall now proceed to explain the process of assaying silver, commonly known by the name of *cupellation.*

Assay of silver.

When we have an assay of silver to make, we flatten the portion of metal upon a polished anvil; the face of the flatting hammer is also highly polished, that the metal may receive no extraneous matter whatever. The piece of metal is flattened to about the thinness of a sixpence, and an assay pound is cut from it, and most accurately weighed in such scales as we have already noticed. This assay pound is then enveloped in a sheet of lead, which is flattened from a lead bullet, and circular, but made into a funnel shape, in order to contain the silver; and the more nicely to prevent any portion of the silver from being lost, the corners of this leaden funnel are closely and firmly folded down. If the assay master has 45, or, indeed, any number short of 45, they are ranged according to their number upon the table, fig. 13. When the furnace and cupels have been prepared according to the number of assays to be made, and when the proper degree of heat has been attained, the assays are charged into the cupels; and the following method is followed in this part of the process:—In the first instance, a ball of lead is charged into each cupel, with the charging tongs (fig. 12), and its weight is according to the quality of the silver to be assayed, the assayer keeping a stock of leaden bullets of different weights for the purpose. As soon as this lead is melted, which is instantaneous, the assays of silver enveloped in lead are also charged into the cupels. The mass is very soon in complete fusion. The mouth of the muffle, which had before been partially closed with cylinders of charcoal about six or seven inches long, and of different diameters suitable to the convenience of the assayers, as represented in fig. 8, is now nearly closed by smaller cylinders of charcoal. The object of this precaution is, that the stream of air admitted to pass over the surface of the cupels, and which is indispensably necessary for the oxidation of the lead in the process of cupellation, may not chill the muffle and retard the progress of the assay. The oxidation of the metal will proceed with more or less rapidity, according as the stream of air admitted is great or small, and which the assayer has it always in his power to regulate at pleasure. The work already referred to in this article has so beautifully and accurately described

Assaying. the progressive appearance of the assay process of silver, that we cannot do better than quote the description:—"The melted metal begins to send off dense fumes, and a minute stream of red fused matter is seen perpetually flowing from the top of the globule down its sides to the surface of the cupel, through which it sinks and is lost to view. This fume and the stream of melted matter consists of the lead oxidated by the heat and air, in one case volatilized, in the other vitrified; and in sinking through the cupel it carries down with it the copper or other alloy of the silver. In proportion to the violence of the heat is the density of the fume, the violence with which it is given off, the convexity of the surface of the globule of melted matter, and the rapidity with which the vitrified oxide *circulates* (as it is termed) or falls down the sides of the metal. As the cupellation advances, the melted button becomes rounder, its surface becomes streaky with large bright points of the fused oxide, which moves with increased rapidity, till at last the globule, being now freed from all the lead and other alloy, suddenly *lightens;* the last portions of litharge on the surface disappear with great rapidity, showing the melted metal bright with irridescent colours, which directly after becomes opaque, and suddenly appears brilliant, clean, and white, as if a curtain had been withdrawn from it. The operation being now finished, and the silver left pure, the cupel is allowed to cool gradually, till the globule of silver is fixed, after which it is taken out of the cupel while still hot, and when cold weighed with as much accuracy as at first. The difference between the globule and the silver at first put in shows the quantity of alloy, the globule being now perfectly pure silver if the operation has been well performed. The reason of cooling the globule or button gradually is, that pure silver, when congealing, assumes a crystalline texture; and if the outer surface is too suddenly fixed, it forcibly contracts on the still fluid part in the centre, causing it to spurt out in aborescent shoots, by which some minute portions are often thrown out of the cupel, and the assay spoiled." (Aikin's *Dictionary.*)

Assay of gold. The assaying of gold, preparatory to the parting process, which we are about to describe, is exactly the same as in the case of silver; the object in the process of cupellation being to destroy the base metal or alloy contained in the gold. If gold contained only copper as alloy, the assaying of gold would be as simple and expeditious as that of silver; but all gold contains a portion of silver, which, though reckoned as alloy, cannot, as we have already seen, be destroyed by cupellation. Recourse is had to the process commonly called the parting process, to get rid of the silver contained in the gold. This is done by means of nitric acid, which entirely dissolves the silver, and leaves the gold perfectly pure. The quantity of silver which gold generally contains is too small to allow the nitric acid to act upon it without addition; and the general allowance by assayers is two or three parts of silver to one of gold. If the quantity of silver greatly exceeded these proportions, the operation would not succeed so well; the fine gold would be obtained in the state of brown powder, the particles having been too minutely divided by the excess of silver.

When assays of gold have passed the test, by which all the alloy, excepting silver, has been destroyed, it is in this process that the additional quantity of silver is added. Suppose, for example, that a gold assay is made from the integer, or pound, weighing 12 grains Troy, an addition of from 24 to 36 grains of pure silver is made in addition to the small portion already supposed to exist in the mass. This becomes thoroughly incorporated with the gold in the process of cupellation. The globule or button, as soon as it is taken from the furnace, is passed between a pair of polished steel rollers, and drawn out into a thin lamina or plate of the thickness of a sixpence, and returned into the furnace to be annealed. After being kept in a red heat for some time, it is taken out and suffered to cool. It is then wound up into a cornet. This is put into a glass matrass, of the shape of an inverted cone, and with about twice or thrice its weight of very pure nitric acid. M. Vauquelin recommends it to be 1·25 specific gravity. But the true test of its strength is in the working of the process. The assayer's attention being directed to the point of strength that will maintain the gold when the silver is extracted in the spiral form, if the acid were too strong, or the silver in too great excess, the gold, as we have already mentioned, would be reduced to powder; and considerable danger exists that it would not be accurately collected, by which an imperfect result would be obtained. The glass matrass is placed upon a sand heat or bath, which is generally a square or oblong pan of copper, with from one to two inches of dry sand in the bottom. The pan is placed over a small square furnace, in which is burning charcoal or coke. As soon as the acid is warm it begins to act upon the silver, and a dense stream of nitrous gas is disengaged. As long as the acid continues to act, the metal appears everywhere to be studded with very minute bubbles, which issue in jets. The disappearance of these, or their uniting into a few large ones, is a sign or mark that the acid has ceased to act. The disappearance also of the nitrous fumes is an indication that the acid has no silver to act upon. In the course of fifteen or twenty minutes the process is finished. But, in order to extend the last portions of silver which the mixture may contain, a small quantity of highly concentrated acid is poured upon the cornet, and boiled, by which the last portions of the silver are extracted. The cornets of gold are thoroughly corroded, but retain the same form, having lost all the silver to two thirds or three fourths of their weight; they are slender and brittle, as we observed before. It is an object of considerable importance to prevent the cornets from being broken, the result being more likely to be accurate than having the gold in fragments; and to prevent this, the quantity of silver used is no more than is absolutely necessary, it being obvious that the less the quantity of gold compared to the silver used in the assay, the more likely is the gold to be broken into pieces.

The hot acid is poured very carefully from the matrass, and warm water is added to wash any remain of silver from the gold, and the addition repeated until the water comes off perfectly clear. The cornets of gold, which are of a dull brown colour and unmetallic appearance, are then put according to their numbers into small clay crucibles, into which they are allowed gently to fall by inverting the matrass, with a portion of water in it, which breaks their fall, and also collects any grains of gold that may be in the matrass. The water is then poured off, and they are put into the furnace, and annealed under a bright cherry heat. When cooled, the pieces of gold have regained their beautiful metallic lustre, and possess all the softness and flexibility of this truly noble metal.

The pieces of gold, thus thoroughly purified, are carefully and accurately weighed, the absolute loss in weight indicating the purity of the metal assayed.

It is a matter of the greatest importance that the silver used in this process should contain no gold, otherwise a source of very material error would arise in the delicate operations of the assayer. Silver generally contains a small portion of gold. Spanish dollars, for example, are found to contain about 4 troy grains in the pound, and are generally preferred in the parting process upon the large scale; but assayers in general use silver revived from a

Assaying. precipitation of the nitrate of silver, which they are sure contains no gold.

The nitrate of silver is precipitated by immersing in it plates of copper, which throw down the silver in the metallic state. It may also be recovered by a solution of common salt, which converts the silver into luna cornea, of which, when washed and well dried, 100 parts contain 75 of silver. The accuracy of the assay may also be proved by this process. The luna cornea, however, is more difficult to reduce to the metallic state, and the mode of recovery by plates of copper is always preferred.

Assaying ‖ Assenheim. French process of assaying.

It remains for us now briefly to mention the process of assaying by the *Petit Fourneau à Coupelle* of Messrs Anfrye and d'Arcet. This process is the same in principle, in all respects, as that which we have been detailing. The only difference consists in the greater facility of the process, and the comparative diminution in the fuel used. The furnace first used by these gentlemen had a small pair of bellows attached to it (see fig. 16); and after the furnace was brought to a proper degree of heat, which required two hours and a half, the following was the result of the experiments made.

Numéros.	Argent Employé.	Plomb Employé.	Durée de l'Essai.	Titres.	Charbon Employé.
1	1 Gram.	4 Gram.	12 Min.	947 Mill.	173 Gram.
2	...	...	11 ...	950 ...	86 ...
3	...	...	13 ...	949 ...	93 ...
4	...	...	10 ...	949 ...	60 ...
Termes Moyens.	1 Gram.	4 Gram.	11·5 Min.	948·75 Mill.	103 Gram.

So that each assay, on an average, was performed in $11\frac{1}{2}$ minutes, and the charcoal used did not much exceed $\frac{1}{4}$th of a pound weight. The standard of the silver used in these experiments was proved by an assay in the ordinary furnace to be 949 millièmes, and the average result by the new furnace was 948·75 millièmes, a difference not more than occurs in the use of the large furnace, and an object of no importance in point of accuracy.

Experiments were also tried with this small furnace, to prove the highest degree of heat that could be produced; and two balls of Wedgwood's pyrometer were put into the furnace, which, when cold, indicated, the one 35, the other 30 degrees, and is fully equal to the heat of the ordinary assay furnace.

When Messrs Anfrye and d'Arcet had improved their furnace by adopting a tube of iron in place of the bellows, they could raise the proper degree of heat in the furnace in half an hour, which required by the original construction two hours and a half.

The following experiments were made upon some five-franc pieces, the standard of which, according to law, should have been from 897 to 903 milimètres:

Numéros.	Argent Employé.	Plomb Employé.	Durée de l'Essai.	Titres.	Charbon Employé.
1	1 Gram.	7 Gram.	15 Min.	900 Mill.	120 Gram.
2	1 ...	7 ...	14 ...	902 ...	123 ...
3	1 ...	7 ...	14 ...	901 ...	175 ...
Termes Moyens.	1 Gram.	7 Gram.	14·33 Min.	901 Mill.	139·33 qrs.

These experiments differ very little from those we have already stated, a trifling increase in the duration of the assay, and in the charcoal consumed, being the only difference; and the greater facility which this furnace has of being raised to the necessary degree of heat, before the assays are charged into the cupels, more than compensates for the increased duration of the assay and charcoal consumed.

This small furnace is particularly recommended for the service of the *Bureaux de Garantie de Province*, where a limited number of assays are from time to time made; and, in point of economy, presents many advantages to recommend it to a place in the chemical laboratory.

This furnace may also be used for a melting furnace; and to convert it to this purpose, the muffle is taken out, and the various apertures, which are open when the assays are making, closed by their respective stoppers: a stand may then be put upon the grate, and a crucible of such size as the furnace will admit, placed upon it, and which can very readily and conveniently be done from the opening *h*, fig. 15. In this use of the furnace coke may be employed instead of the charcoal, the heat being greater and more steady with the former than the latter. (E. E.)

ASSELYN, John, a famous painter, was born in Holland, and became the disciple of Isaiah Vandervelde, the battle-painter. He distinguished himself in history-painting, battles, landscapes, animals, and particularly horses. He travelled into France and Italy, and was so pleased with the manner of Bambochio that he always followed it. He painted many pictures at Lyons, where he married the daughter of a merchant of Antwerp, and returned with her to Holland. Here he first discovered to his countrymen a fresh and clear manner of painting landscapes like Claude Lorraine; upon which all the painters imitated his style, and reformed the dark brown they had hitherto followed. Asselyn's pictures were so much admired at Amsterdam that they sold there at a high price. He died in that city in 1660. Twenty-four pieces of landscapes and ruins, which he painted in Italy, have been engraved by Perelle.

ASSEMBLY, the meeting of several persons in the same place, upon the same design. Assemblies of the clergy are called *convocations*, *synods*, *councils*. The annual meeting of the church of Scotland is called a *General Assembly*.

ASSEN, a town of the Netherlands, capital of the province of Drenthe, containing 1173 inhabitants. It is a lively and pleasant place, being on the road between Groningen and Zwole.

ASSENDE, a market-town, with 3314 inhabitants, in the circle of Ceclo and province of East Flanders. It is in long. 3. 59. 22. E. and lat. 51. 13. 49. N.

ASSENHEIM, a jurisdiction belonging to the mediatized Count of Solme Rodelheim, now in the dominions of

the prince of Hesse Cassel, in Germany, containing one city, ten villages, 654 houses, and 3957 inhabitants. The chief place of the bailiwick is of the same name, and contains 615 inhabitants.

ASSENS, a sea-port town of Denmark, situated upon the Little Belt, a strait of the Baltic which separates the isle of Funen from the continent. It is the common passage from the duchy of Sleswick to Copenhagen. Long. 10. 30. E. Lat. 55. 15. N.

ASSER, John, or Asserius Menevensis, that is, *Asser of St David's*, bishop of Sherburn in the reign of Alfred the Great. He was born in Pembrokeshire in South Wales, and educated in the monastery of St David's by the archbishop Asserius, who, according to Leland, was his kinsman. In this monastery he became a monk, and by his assiduous application soon acquired universal fame as a person of profound learning and great abilities. Alfred, the munificent patron of genius, about the year 880 sent for him to court. The king was then at Dean in Wiltshire. He was so charmed with Asser that he made him his preceptor and companion. As a reward for his services, he appointed him abbot of two or three different monasteries; and at last promoted him to the episcopal see of Sherburn, where he died and was buried in the year 910. He was, says Pitts, a man of happy genius, wonderful modesty, extensive learning, and great integrity of life. He is said to have been principally instrumental in persuading the king to restore the university of Oxford to its pristine dignity and lustre. He wrote *De Vita et Rebus Gestis Alfredi*, first published by Archbishop Parker in the old Saxon character, at the end of *Walsinghami Hist.* Lond. 1574. It was reprinted at Frankfort in 1603, in folio, and in 8vo at Oxford in 1722. Various other works have been ascribed to this author by Pitts and by Leland.

ASSESSOR, an inferior officer of justice, appointed chiefly to assist the ordinary judge with his opinion and advice.

ASSETS, in *English Law*, are real or personal. Where a man hath lands in fee-simple, and dies seised thereof, the lands which come to his heirs are assets real; and where he dies possessed of any personal estate, the goods which come to the executors are assets personal.

ASSHETON, William, doctor of divinity, and rector of Beckenham in Kent, was born in the year 1641, and was educated at Brazen-nose College, Oxford. After entering into orders he became chaplain to the duke of Ormond, and was admitted doctor of divinity in 1673. Soon after he was nominated to a prebend in the church of York, presented to the living of St Antholin, London, and to the rectory of Beckenham in Kent. He was the first projector of the scheme for providing for clergymen's widows and others, by a jointure payable out of the mercers' company. He wrote several pieces against the papists and dissenters, and some devotional tracts. He died at Beckenham in September 1711, in the 70th year of his age.

ASSIDEANS, or Chasidæans (from the Hebrew *chasidim*, merciful, pious), those Jews who resorted to Mattathias to fight for the law of God and the liberties of their country. They were men of great valour and zeal, having voluntarily devoted themselves to a more strict observance of the law than other men; for after the return of the Jews from the Babylonish captivity there were two sorts of men in their church,—those who contented themselves with that obedience only which was prescribed by the law of Moses, and who were called *Zadikim*, i. e. the *righteous*,—and those who, over and above the law, superadded the constitutions and traditions of the elders, and other rigorous observances: these latter were called *Chasidim*, i. e. the *pious*. From the former sprung the Samaritans, Sadducees, and Caraites; from the latter the Pharisees and the Essenes.

ASSIENTO, a Spanish word signifying a *farm*, in commerce, is used to denote a treaty between the king of Spain and other powers, for importing negroes into the Spanish dominions in America.

ASSIGNATION, in the law of Scotland, is the term applied to the transference of a right by deed of conveyance.

ASSIMILATION, in *Physics*, is that motion by which bodies convert other bodies into their own substance and nature.

ASSIN, an African country of considerable extent, situated in the interior, now comprehended under the dominion of Ashantee.

ASSISSI, a city in the delegation of Perugia, in the papal territory of Italy. It contains 20 churches, 12 monasteries for begging friars, and about 4000 inhabitants, mostly poor, and depending for subsistence on the saintly devotees, who, to the number of many thousands, make annual pilgrimages to the cathedral, which contains the tomb of St Francis, the founder of the Franciscan order. Long. 12. 29. 23. E. Lat. 43. 4. 22. N.

ASSITHMENT, a wiregeld, or composition, by a pecuniary mulct; from the preposition *ad*, and the Sax. *sithe, vice; quod vice supplicii ad expiandum delictum solvitur.*

ASSIZE, in old English law-books, is defined to be an assembly of knights and other substantial men, together with a justice, in a certain place and at a certain time; but the word, in its present acceptation, implies a court, place, or time, when and where processes, whether civil or criminal, are decided by judge and jury.

ASSOCIATION, the act of associating or constituting a society or partnership, in order to carry on some scheme, affair, or business, with more advantage. The word is Latin, *associatio;* and compounded of *ad*, to, and *socio*, to join.

Association of Ideas. See Metaphysics.

ASSODNAGUR, a town of Hindostan, in the province of Bejapoor, the capital of a Mahratta district of the same name, 68 miles S.E. from Poonah. Long. 74. 55. E. Lat. 18. 6. N.

ASSOILZIE, in *Law*, to absolve or free by sentence of court.

ASSONANCE, in *Rhetoric* and *Poetry*, a term used where the words of a phrase or a verse have the same sound or termination, and yet make no proper rhyme. These are usually accounted vicious in English, though the Romans sometimes used them with elegance, as *Militem comparavit, exercitum ordinavit, aciem lustravit.*

ASSONANT Rhymes is a term particularly applied to a kind of verses common among the Spaniards, where a resemblance of sound serves instead of a natural rhyme. Thus *ligera, cubierta, tierra, mesa*, may answer each other in a kind of *assonant* rhyme, having each an *e* in the penult syllable, and an *a* in the last.

ASSUMPSIT, in the *Law of England*, a voluntary promise, whereby a person assumes or takes upon him to perform or pay any thing to another.

ASSUMPTION, a festival in the Romish church, in honour of the miraculous ascent of the Virgin Mary into heaven. The Greek church also observes this festival, and celebrates it on the 15th of August with great ceremony.

Assumption, in *Logic*, is the minor or second proposition in a categorical syllogism.

Assumption, or Assongong, one of the Marianne or Ladrone Islands, in the Pacific Ocean, of a conical figure, and 600 feet in height. It is of a dreary aspect, and almost totally covered with lava from the eruptions of a volcano in the centre. It has no anchorage near the shore. Long. 140. 55. E. Lat. 19. 45. N.

Assumption. Assyria.

ASSUMPTION, an island in North America, in the Gulf of St Lawrence, at the mouth of the great river of the same name. Long. 60. 40. W. Lat. 49. 30. N.

ASSUMPTION, the capital city of the province of Paraguay in South America. It is situated on an obtuse angle formed by the eastern bank of the river Paraguay, 18 miles above the junction of the first mouth of the Pilcomayo, and 48 above that of the second. It was originally a small fort, but, from the convenience of its situation, in a few years it became a city, and in 1547 was erected into a bishopric. The adjacent territory is rich and fertile in a high degree, and abounds in a great variety of fruits. The air is temperate and the climate salubrious; the trees are perpetually green, and the rich pastures in the neighbourhood feed numerous flocks of cattle. The city is inhabited by Spaniards, Indians, and Mestizoes, who trade in hides, tobacco, and sugar. The Paraguay affords a channel of communication between Buenos Ayres and this place; but the passage is long, owing to the rapid flow of the waters of that river: this, however, is considerably obviated by the favourable winds which blow from the south for a great part of the year. Long. 59. 35. W. Lat. 24. 47. S.

ASSUMPTIVE ARMS, in *Heraldry*, are such as a person has a right to assume with the approbation of his sovereign and of the heralds.

ASSURANCE, or INSURANCE. See INSURANCE.

ASSYE, a small town of Hindostan, in the province of Berar, 24 miles N.N.E. from Jalnapoor, noted for a battle fought near it in September 1803, between a force of 4500 men under General Wellesley, afterwards the Duke of Wellington, and the combined armies of Sindia and the rajah of Nagpoor, amounting to 30,000 men, in which the British were victorious, though with severe loss. Long. 76. 40. E. Lat. 20. 14. N.

ASSYN-KALESI, a village of Asia Minor, in Caria, occupying a peninsula among the branches of Mount Grius, with a mean but extensive fortress on the summit of the rock. This village stands on the site of the ancient Jasus, a considerable city, and many antiquities are still to be seen in it. Some of the most spacious sepulchres are at present inhabited by Greek families as their ordinary dwellings. Long. 27. 32. E. Lat. 37. 18. N.

ASSYRIA, an ancient kingdom of Asia, concerning the commencement, duration, and extent of which historians are not agreed. Ctesias and Diodorus Siculus describe the Assyrian monarchy, under Ninus and Semiramis, as of very great extent; but the silence of Homer, and the brief statements of Herodotus, are not easily reconciled with this opinion; and there is no mention of the greatness of Assyria in the history of the judges and succeeding kings of Israel, though during that period the latter kingdom was oppressed and enslaved by different powers. According to Ptolemy, Assyria was bounded on the north by Armenia Major, on the west by the Tigris, on the south by Susiana, and on the east by Media; but the name is generally used in a more comprehensive sense, so as to include Mesopotamia, and sometimes even Babylonia and Chaldea. The most common account of the origin and revolutions of the Assyrian monarchy is the following:—The founder of it was Ashur, the second son of Shem, who, removing out of Shinar, either by the appointment of Nimrod or to elude the fury of a tyrant, conducted a large body of adventurers into Assyria, and laid the foundation of Nineveh (Gen. x. 11). These events happened not long after Nimrod had established the Chaldean monarchy, and fixed his residence at Babylon. The Persian historians suppose that the kings of Persia of the first dynasty were the same with the kings of Assyria, of whom Zohah or Nimrod was the founder of Babel. It does not, however, appear that Nimrod reigned in Assyria. The kingdoms of Babylon and Assyria were originally distinct and separate (Micah v. 6); and in this state they remained until Ninus conquered Babylon and made it tributary to the Assyrian empire. Ninus, the successor of Ashur (Gen. x. 11. Diod. Sic. lib. 1), seized on Chaldea after the death of Nimrod, and united the kingdoms of Assyria and Babylon. This great prince is said to have subdued Asia, Persia, Media, Egypt, and other countries. If he did so, the effects of his conquests were of no duration; for in the days of Abraham we do not find that any of the neighbouring kingdoms were subject to Assyria. He was succeeded by Semiramis, a princess of a heroic mind; bold, enterprising, fortunate; but of whom many fabulous things have been recorded. It appears, however, that there were two princesses of the same name, who flourished at very different periods. Whether there was an uninterrupted series of kings from Ninus to Sardanapalus or not, is still a question. Some suspicion has arisen that the list which Ctesias has given of the Assyrian kings is not genuine; for many names in it are of Persian, Egyptian, and Grecian extraction. Nothing memorable has been recorded concerning the successors of Ninus and Semiramis. Of that effeminate race of princes it is barely said that they ascended the throne, lived in indolence, and died in their palace at Nineveh. Diodorus (lib. ii.) relates, that, in the reign of Teutames, the Assyrians, solicited by Priam their vassal, sent to the Trojans a supply of 20,000 foot and 200 chariots, under the command of Memnon, son of Tithonus president of Persia. But the truth of his relation is rendered more than doubtful by the accounts of other writers. Sardanapalus was the last of the ancient Assyrian kings. Contemning his indolent and voluptuous course of life, Arbaces, governor of Media, withdrew his allegiance, and rose up in rebellion against him. He was encouraged in this revolt by the advice and assistance of Belesis, a Chaldean priest, who engaged the Babylonians to follow the example of the Medes. These powerful provinces, aided by the Persians and other allies, who despised the effeminacy or dreaded the tyranny of their Assyrian lords, attacked the empire on all sides. Their most vigorous efforts were in the beginning unsuccessful. Firm and determined, however, in their opposition, they at length prevailed, defeated the Assyrian army, besieged Sardanapalus in his capital, which they demolished, and became masters of the empire, B. C. 821.

After the death of Sardanapalus the Assyrian empire was divided into three kingdoms, viz. the Median, Assyrian, and Babylonian. Arbaces retained the supreme power and authority, and fixed his residence at Ecbatana, in Media. He nominated governors in Assyria and Babylon, who were honoured with the title of *kings*, while they remained subject and tributary to the Median monarchs. Belesis received the government of Babylon as the reward of his services, and Pul was intrusted with that of Assyria. The Assyrian governor gradually enlarged the boundaries of his kingdom. He invaded Israel, and compelled the usurper Menahem to relinquish the independency of his kingdom, and pay 1000 talents of silver. It is probable that other nations submitted to the power of his arms. The Syrians were either propitiated by an alliance, or reduced by compulsion, to allow his army to cross their country on his invasion of Israel, for through it he must have marched. On Nabonasser he bestowed the sovereignty of Babylon, and left his elder son Tiglathpileser heir of his Assyrian dominions. This prince also invaded Israel, and carried more than one of the ten tribes captive to Assyria. The dominions of Ahaz king of Judah being invaded by the confederate hosts of the kings of Israel and Syria, that prince despoiled the temple of

its gold and silver, and, along with the treasure of his palace, purchased the support of Tiglath-pileser, who, entering the Syrian dominions, vanquished and slew their monarch, and fulfilled the predictions of the prophets Isaiah and Amos, by bringing that ancient kingdom to an end. Tiglath-pileser died in the midst of his career of victory, and was succeeded by Shalmaneser, who carried the war into the dominions of Hoshea king of Israel, whom he reduced to submission, imposing an annual tribute upon the kingdom. Hoshea, in attempting to shake off this yoke, again brought upon himself the vengeance of Shalmaneser, who once more subjected the country, and laid siege to Samaria, which capitulated after a defence of three years. Hoshea was put in chains and thrown into prison, and the inhabitants were led into captivity. Hezekiah, king of Judah, also set at defiance the power of Assyria by refusing tribute; but he chose the time for this revolt with greater judgment than Hoshea. The Assyrians were at that period engaged in an unsuccessful war with the Tyrians, during the prosecution of which Shalmaneser died, and was succeeded by Sennacherib, who invaded Judah; upon which Hezekiah, to purchase peace, sent him all the gold and silver with which the temple, as well as his own house, was decorated. The treaty, however, was no sooner concluded than it was trampled upon by Sennacherib, who sent an army to besiege Jerusalem. But the leaders, while haranguing the people who were upon the walls, blasphemed against God, for which, as the sacred historian informs us, they were signally punished, 185,000 of the Assyrians being cut off in one night by the angel of the Lord. This terrible destruction forced him back to his own dominions, where he exercised such tyranny over his subjects that he was assassinated by two of his own sons. Esar-haddon, his third son, ascended the throne, and extended the Assyrian dominions by the conquest of Babylon, Israel, and Syria, and the subjugation of Judah, Egypt and Ethiopia. After the death of Esar-haddon only a few princes appear to have ascended the throne of Assyria, and the kingdom at last was split, and annexed to those of Media and Babylon. Several tributary princes afterwards reigned in Nineveh; but no particular account of them is found in the annals of ancient nations. We hear no more of the kings of Assyria, but of those of Babylon. Cyaxares king of Media assisted Nebuchadnezzar king of Babylon in the siege of Nineveh, which they took and destroyed B. C. 606. The Chaldean or Babylonish kingdom was transferred to the Medes after the reign of Nabonadius, son of Evilmerodach, and grandson of Nebuchadnezzar. He is styled Belshazzar in the sacred records, and was conquered by Cyrus B. C. 538.

ASTABAT, a town of Persian Armenia, situated near the river Aras, the ancient Araxes, 20 miles south-east of Nacsivan. It is a small but neat place, and each house is supplied with a well of water. The neighbouring country is fertile, and produces good wine. There is a root peculiar to this country, called *ronas*, used for dyeing red, great quantities of which are cultivated by the inhabitants and exported to India. Long. 46. 30. E. Lat. 39. N.

ASTAFORT, a town of France, in Gascony. It is the head of a canton in the department of the Lot and Garonne, arrondissement of Agen, and contains 4140 inhabitants.

ASTANDA, in *Antiquity*, a royal courier or messenger, the same with ANGARUS. King Darius of Persia is said by Plutarch, in his book on the fortune of Alexander, to have formerly been an *astanda*.

ASTARA, a town of Persia, and capital of a district, the governor of which is independent of Ghilan and Schirvan. It is situated on the river Astara. 70 miles N. of Reshd, and 100 E. of Tabriz. Long. 49. E. Lat. 38. 20. N.

ASTARAKAT, a town of Persia, in the province of Segistan or Seistan. 100 miles N. of Zareng; 220 W.N.W. of Candahar.

ASTAROTH, or ASHTAROTH, in *Antiquity*, a goddess of the Sidonians. The word is Syriac, and signifies *sheep*, especially when their udders are turgid with milk. From the fecundity of these animals, which in Syria continue to breed a long time, they formed the notion of a deity, whom they called *Astaroth* or *Astarte*. Solomon, in compliment to one of his queens, erected an altar to her. In the reign of Ahab, Jezebel caused her worship to be performed with much pomp and ceremony; she had 400 priests; the women were employed in weaving hangings or tabernacles for her; and Jeremiah observes, that "the children gathered the wood, the fathers kindled the fire, and the women kneaded the dough, to make cakes for the queen of heaven."

ASTELL, MARY, an English authoress of some name, was born at Newcastle-upon-Tyne in the year 1668. Her father, who was a merchant, committed the education of his daughter to her uncle, who was a clergyman. Convinced of the general injury done to young ladies at that period by the deficiency of their education, he taught her the Latin and French languages, and instructed her in the principles of logic, mathematics, and natural philosophy. Having spent 20 years of her life in Newcastle, she went to London, where she continued the pursuit of her studies; and, deeply affected with the general ignorance of her sex, she employed the first fruits of her pen to rouse them to a proper emulation, in a work entitled *A Serious Proposal to the Ladies, wherein a Method is offered for the Improvement of their Minds*, printed in 12mo, at London, 1697. The chief object of this work was to recommend the erection of a seminary for female education. She next wrote a book entitled *Reflections on Marriage*, which was published in 1700. This lady was a zealous advocate for the religious system commonly called *orthodox*, and in politics defended the doctrine of non-resistance. About this time she published some controversial pieces, among which are the following:—Moderation Truly Stated; A Fair Way with the Dissenters; An Impartial Enquiry into the Causes of the Rebellion; and A Vindication of the Royal Martyrs; all printed in 4to, in 1704. Her most finished performance was, The Christian Religion, as professed by a Daughter of the Church of England; published in 1705, in a large octavo volume. She died in the year 1731.

ASTELL'S ISLAND, one of the English Company's islands, at the north-west part of the Gulf of Carpentaria, of moderate height, and wooded. Iron ore is found here. Lat. 11. 55. S.

ASTERIA or STAR-STONE. This name is given to certain varieties of the perfect corundum, when cut in a peculiar manner. The structure of this gem is that of a hexagonal prism, surmounted by a double hexagonal pyramid, which, when cut perpendicular to the axis, and rounded off in the form of a ring-stone, very often presents, when held up to a strong light, a distinct star of six rays. This phenomenon frequently occurs in sapphires and rubies, and, when perfect, the gem is highly prized.

The same name has been given to the joints of an extraneous fossil, merely from the form they present.

ASTERISK, a mark in form of a star (*), placed over a word or sentence, to refer the reader to the margin, or elsewhere, for a quotation, explanation, or the like.

ASTERN, a sea phrase, used to signify any thing at some distance behind the ship; being the opposite of AHEAD, which signifies the space before her.

ASTI, a province of the duchy of Piedmont, in the

continental dominions of the king of Sardinia. It is bounded on the north-east and east by Alessandria, on the south-east by Aqui, on the south-west by Alba, and on the west and north-west by Turin. It extends over 400 square miles, or 256,000 acres. It is a plain, with gentle undulations, watered by the Tanaro and the Po; fruitful in all the productions of Italy, but more especially in corn, wine, and silk. It contains one city and 109 towns and villages, inhabited by 110,623 persons.

Asti, the capital of the above province, is a large and well-built town, standing on the left bank of the Tanaro, in Upper Italy. It is the see of a bishop, who is a suffragan of the archbishop of Turin. It contains many churches and monastical institutions, with 22,000 inhabitants, who carry on a considerable trade in corn, wine, and silk, which is not a little promoted by the situation of the town on the high road from Alessandria to Turin and Coni. 20 miles W. of Alessandria, and 24 E. of Turin.

ASTOMI, in anthropology, a people feigned without mouths. Pliny speaks of a nation of Astomi in India, who lived only by the smell or effluvia of bodies taken in by the nose.

ASTORGA, a city of Spain, in the province of Leon, situated on a plain near the river Tuerto, and having the appellation of a marquisate, which title it confers on a noble family. It is surrounded with ancient fortifications, and has near it a castle in ruins. It has a cathedral, being the see of a bishop under the church of Compostella. It was called "the city of priests," from the great numbers of that profession that were formerly resident within its walls. It contains 2000 inhabitants. Long. 5. 38. 53. W. Lat. 42. 27. 9. N.

ASTRABAD, or Asterabad, a small province of Persia, sometimes included in that of Mazanderan. It is bounded on the west by the Caspian Sea; to the south it is separated by a lofty ridge of mountains from the districts of Damgan and Bistan; it extends to 58° of east longitude, where it is divided from Dahistan by the river Ashor. The country, although mountainous, and interspersed with deep forests, in which it is scarcely possible to travel, possesses beautiful and fertile valleys, producing rice, wheat, and other grains in abundance, or spread out in a boundless expanse of verdure, the pasturage of numerous flocks and herds. Fraser, who travelled through Persia in 1822, extols in the most lavish terms the appearance of the country. "There is no describing," he observes, "the beauty and richness of these pastures; all is like velvet, smooth and soft, varying only in the height, not in the thickness, of the sward." The soil, with little culture, is exceedingly productive, owing to the abundance of water which irrigates and fertilizes it. But while the province in many parts presents a landscape of luxuriant beauty, it is a prey to the ravages of disease, and the frequent incursions of the surrounding tribes. The heavy torrents which fall in the rainy season stagnate in the forests, forming morasses which, in the heats of summer and autumn, exhale a pestilential vapour, from the decomposition of the vegetable matter they contain. From these seats of noxious effluvia the wandering tribes of shepherds fly beyond the Goorgaun or the Attruck, and live on the verge of the burning sand, although they have to carry water for each day's consumption from the distant river. The better classes retire from the intense heats of summer into the mountains; but the settled inhabitants of the villages, who cannot so easily remove, and who generally remain, suffer severely from sickness. Intermittent and putrid fevers, dropsies, and all those ailments which proceed from cold or from unwholesome air, prevail. The inhabitants, notwithstanding the unhealthiness of their climate, are a stout and athletic race. The revenue derived from this province by the king of Persia does not exceed the value of L.7000 sterling. It is famous, however, for furnishing a supply of matchlocks, or toffunchees as they are called, from toffuny, a gun or matchlock, with which the troops who generally attend upon the king's person are armed. This is the ancient Hyrcania, and is the native country of the Kadgers, a Turkish tribe, of whom the king is the head, and on whom he considers he can rely in times of danger.

Astrabad or Asterabad, a town of Persia, the capital of the above province, is situated on the south-east shore of the Caspian Sea, at the mouth of the river Aster or Ester, and at the head of an admirably sheltered bay, extremely convenient for shipping. This bay is formed by a neck of land, varying in breadth from 4 to 12 miles, which runs from a point near Astrabad for about 70 miles eastward, dividing a strip of water from 8 to 40 miles broad from the main body of the Caspian Sea. Astrabad is an ancient city, and owes its origin to Yezzen-ibn-Messlub, an Arab chief of great celebrity, who commanded the armies of Soliman, the seventh caliph of the Ommiades, about the beginning of the seventh century. It was destroyed by Tamerlane. In 1744 Hanway visited this place, and attempted to open a direct trade with it from Europe. It is a pleasant, well-built town, about $3\frac{1}{2}$ miles in circuit, and highly picturesque in appearance, from the buildings being intermingled with trees and extensive gardens. It was formerly larger, but Nadir Shah contracted it within its present limits. A mound of earth surrounds it, the remains of a mud wall once lofty and formidable, and defended by numerous towers, and also by a wide and deep ditch, now almost filled with rubbish. The only fortification it possesses is a small parapet, supplied with loop-holes for musketry, raised upon the mouldered wall. The streets and lanes are paved with stone, always kept in good repair; and a drain runs down their centre, a provision of infinite importance in this rainy climate, where the torrents which fall and are thus carried off would otherwise plough up and destroy the streets, or be allowed to stagnate in pools. The houses are constructed chiefly of wood, and are frequently furnished with verandas; their style of architecture is light and open, the roofs covered with red tiles, and sometimes with thatch. Many houses are provided with square towers, having openings, such as are used in other eastern towns, for ventilating the rooms. They have a good effect when seen from a distance, presenting the appearance of spires. Astrabad has but little trade; and the bazaars or public markets, though extensive, are but poorly filled, containing little more than the necessary supplies for the consumption of the place. There are no public buildings deserving of notice. The number of houses within the walls is estimated at from 2000 to 3000. The town is extremely unhealthy during the hot weather, owing to the damp and noxious exhalations of the surrounding forests. Astrabad is 400 miles north-east of Ispahan. Long. 54. 25. E. Lat. 36. 50. N.

ASTRACAN, a large city of Asiatic Russia, the seat of an archbishop, built on eminences surrounded by the marshes of the Volga, between 50 and 60 miles from its influx into the Caspian Sea. It is about three miles in circumference, or nearly five miles if we include the suburbs, and is surrounded by a wall mostly in a ruinous condition. This city was anciently the capital of a kingdom belonging to the Tartars, who were expelled in 1554 by the Russian prince Iwan Basilowitz. In 1569 it was besieged by the Turks, who were defeated with great slaughter by the Russians. In 1672 it was seized by the rebel Slenkorazin. Since that period it has suffered from conflagrations, being formerly composed of mean and inconvenient buildings of wood. But in the modern city attention has been paid both to its safety and embellishment, by the

erection of more spacious and elegant houses and public edifices of stone. The high price of timber has contributed to bring about this improvement, the inhabitants finding it cheaper to use in their modern erections either brick or a species of freestone found in a quarry near the banks of the Volga. Of the public buildings, the most conspicuous are the two commercial halls for the reception and sale of merchandise, both finished in an elegant style of architecture, one of which is appropriated to the Armenians and the other to the Persians. The kremlin, which is uninhabited, stands on a hill, and contains the cathedral, a spacious brick edifice. There are, besides, in this city two convents, twenty-five Russian and one Roman Catholic church. Some votaries of Brahma, natives of Moultan, also reside at Astracan; and the Armenians have a metropolitan church, which is surmounted by a cupola, where, in the course of the worship, Pallas saw exhibited by the suffragan or archimandrite the holy oil prepared in Mount Ararat, and which is held sacred by the inhabitants. In the vicinity of this city are numerous vineyards, which being irrigated by the waters of the Volga, produce abundantly; and a considerable quantity of wine is manufactured, and exported to Petersburg, Moscow, and other places. The situation of Astracan is favourable for trade; and it is accordingly a great commercial mart between Asia and Europe. By means of the river Volga, the commodities of Eastern Asia are carried into the heart of Russia, while the produce of Russia, or European goods imported, are brought down to the Caspian Sea, and transported across to Resht, Lahajan, Balfroosh, and Astrabad, whence they find their way into Persia and the East. Goods are also sent by sea to Mangushluck, on the eastern shore of the Caspian Sea, and thence eastward to Khyvah, a distance of 250 miles, and afterwards to Buckharia, a distance of 250 more. The shipping employed in this trade does not exceed, according to the estimate made by Fraser in his account of the commerce of Persia, 12 vessels of from 50 to 100 tons. These vessels belong to Russian or Mahometan merchants settled at Astracan. Two caravans besides, each of 500 camels, set out from Astracan eastward for Khyvah and Buckharia. The exports from Astracan eastward are iron, steel, copper, quicksilver, leather, furs, cotton, woollen, silk, and other manufactured goods of Europe; and the imports consist of fruits, grain, rice, timber, tobacco, raw hides, lambskins, drugs, turquoises, from Buckharia; silk goods, gold and silver brocades, from Persia; and shawls from Thibet and Cashmere. The fisheries on the Volga, in which are caught the sturgeon and the beluga or great sturgeon, are of great extent and importance. From the sounds of these fish are made isinglass and caviare, the demand for which has been increasing for many years. There is not, except on the banks of Newfoundland, a more productive fishery. During the fasts of the Greek church, which continue for about one third of the year, the sturgeon affords the chief food to European Russia and its populous cities. Many thousands acquire wealth either by fishing or by conveying and retailing the fish in the markets. The population of Astracan is 70,000, composed of Russians, Armenians, Greeks, Tartars, Persians, Jews, Indians, English, and French; but the most numerous are the Tartars and Armenians. In 1830 the inhabitants suffered severely from the cholera morbus. 330 miles S.S.E. Saratov, 1040 S.S.E. Petersburg. Long. 47. 44. E. Lat. 46. 21. N.

Astracan was formerly the name of an independent government of Asiatic Russia, but in 1785 was incorporated with that of Caucasus. It was of considerable extent, but thinly peopled on account of the barrenness of the soil, except on the banks of the Volga, the Ural, and their tributary streams. (Pallas's *Travels;* Tooke's *Russia.*)

ASTRÆA, in *Astronomy*, a name which some give to the sign Virgo, by others called *Erigone*, and sometimes *Isis*. The poets feign that Justice quitted heaven to reside on earth in the golden age; but growing weary of the iniquities of mankind, she left the earth and returned to heaven, where she commenced a constellation of stars, and from her orb still looks down on the ways of men.

ASTRAGALOMANCY, a species of divination performed by throwing small pieces, with marks corresponding to the letters of the alphabet, the accidental disposition of which formed the answer required. This kind of divination was practised in a temple of Hercules in Achaia. The word is derived from *αστραγαλος*, and *μαντεια*, *divination.*

ASTROGNOSIA, the science of the fixed stars, or the knowledge of their names, constellations, magnitudes, &c.

ASTROLABE, the name for a stereographic projection of the sphere, either upon the plane of the equator, the eye being supposed to be in the pole of the world, or upon the plane of the meridian, when the eye is supposed in the point of the intersection of the equinoctial and horizon.

Astrolade is also the name of an instrument formerly used for taking the altitude of the sun or stars at sea.

Astrolade, among the ancients, was the same as our armillary sphere.

ASTROLOGY, a pretended science, teaching to judge of the effects and influences of the stars, and to foretel future events by the situation and different aspects of the heavenly bodies.

This science was divided into two branches, *natural* and *judiciary*. To the former belonged the predicting of natural effects; as the changes of weather, winds, storms, hurricanes, thunder, floods, earthquakes, &c. Judiciary or judicial astrology is that which pretended to foretel moral events, as if they were directed by the stars. It is commonly said to have been invented in Chaldea, and thence transmitted to the Egyptians, Greeks, and Romans; though some will have it of Egyptian origin. At Rome the people were so infatuated with it, that the astrologers, or, as they were then called, the *mathematicians*, maintained their ground in spite of all the edicts of the emperors expelling them from the city. The same superstition has prevailed in modern nations. The French historians tell us, that in the time of Queen Catherine d' Medici, astrology was so much in vogue that the most inconsiderable thing was not to be done without consulting the stars. And in the reigns of king Henry III. and IV. of France, the predictions of astrologers were the common theme of the court conversation.

ASTRONOMY.

History. ASTRONOMY, from αστηρ or αστρον, *a star*, and νομος, *a law*, is the science which treats of the laws observed by the stars in their motions. By an extension of signification, it embraces every thing that is known relating to the nature and constitution, as well as to the motions, of the celestial bodies.

The present treatise is divided into Four Parts. In the *First*, which contains the History of Astronomy, the progressive advancement of the science from the times of the Chaldeans and Egyptians to the present day is briefly sketched, and the labours of those illustrious individuals commemorated, who have either theoretically or practically contributed most to its progress. The *Second Part*, which we have denominated Theoretical Astronomy, is devoted to a general view of the science,—to the explanation of the different theories and methods by which the motions of the celestial bodies are represented, and their places computed; and the description of such facts as observation has made known respecting their nature and constitution. *Part Third* treats of Physical Astronomy; and *Part Fourth* of Practical Astronomy. History.

PART I.

HISTORY OF ASTRONOMY.

Astronomy, if we dignify by that name the first rude attempts that were made to discover the order and connection of the celestial motions, may probably be regarded as the most ancient of all the sciences. In fact, a certain degree of attention to the heavenly bodies is forced even on the savage who inhabits the forest, and derives his subsistence from the spontaneous productions of the earth. The regular vicissitude of day and night inevitably compels him to observe the diurnal course of the sun; and he cannot fail soon to perceive, that the variety and succession of the seasons is equally dependent on the oblique annual course of the same great luminary. The moon, too, in the absence of the sun, is an object so conspicuous, so consoling, and so useful, that her motions must at all times have been watched with attention and interest; while her various phases, her alternate waxings and wanings, her regular disappearance and return after equal intervals of time, would be contemplated with admiration and delight. Nor are the wonders of the starry firmament less calculated to strike even the most heedless observer of the heavens. The magnificent spectacle of the sky bespangled with brilliant points, and revolving in obedience to eternal and unalterable laws, affords a constant succession of new objects of sublime and exalted contemplation. The occasional recurrence, also, of eclipses and other unusual phenomena, which seem to interrupt the general order and uniformity of the celestial motions, would stimulate to attentive observation; for the vanity of man has in all ages rendered him eager to connect his own destiny with the heavens, while his timidity has prompted him to regard every apparent deviation from the ordinary course of events as an emblem of the wrath, and a precursor of the vengeance, of superior beings.

But though mankind were probably first impelled by motives of mere curiosity to observe the courses of the stars, no great length of time could elapse ere they perceived that the regular and uniform revolutions of the heavens might be rendered subservient to their own wants and conveniencies. By the help of the stars the shepherd, during the night, could count the hours, the traveller track his course through the uniform wastes of the desert, and the mariner guide his bark over the ocean: the husbandman, also, learned to regulate his labours by the appearance of certain constellations, which gave him warning of the approaching seasons. The indications derived from the simple observation of such phenomena were doubtless extremely vague; but as civilisation advanced, the necessity of determining accurately the length of the solar year and of the lunar month, in order to regulate the calendar and the religious festivals, led to the accumulation and comparison of different observations, whereby errors were gradually diminished, and the foundations laid of a more perfect acquaintance with the heavenly motions.

Astronomy, presenting so many objects of interesting curiosity, and having so many practical uses, could not fail to be one of the sciences first cultivated by mankind. Its origin is consequently hid amidst the obscurity and traditions of the remotest ages, and is in fact coeval with the origin of society, and the earliest development of the human intellect. The records or traditions of almost every ancient nation furnish some traces of attention to the state of the heavens, and of some rude attempts to discover the laws, the order, and the period of the most remarkable phenomena,—such as eclipses of the sun and moon, the motions of the planets, and the heliacal risings of the principal stars and constellations. The Chaldeans and Egyptians, Chinese and Indians, Gauls and Peruvians, equally regard themselves as the inventors of astronomy; an honour, however, of which Josephus deprives them all, in order to ascribe it to the antediluvian patriarchs. The fables relating to the two columns of brick and marble which these sages are said to have erected, and on which they engraved the elements of their astronomy, to preserve them from the universal destruction by fire and water to which, they are said to have learned from Adam, the earth was doomed, are not worth the trouble of repetition; nor is there any better proof than the assertion of that credulous historian, of their acquaintance with the *annus magnus*, or, as is most probably supposed, the astronomical cycle of 600 years, which brings back the sun and moon to the same points of the heavens so nearly, that its discovery implies a pretty correct knowledge of the solar and lunar motions. Passing over, therefore, those periods that present us only with a scanty detail of traditional observations or unimportant facts, we will proceed to give a brief account of the state of astronomy among some early nations who have undoubtedly contributed to the improvement of the science, or who, at least, have transmitted to future ages some monuments of their

History. astronomical labours, and of their attention to celestial observations.

Astronomy of the Chaldeans, Egyptians, Phœnicians, Chinese, and Indians.

Chaldeans. According to the unanimous testimony of the Greek historians, the earliest traces of astronomical science are to be met with among the Chaldeans and Egyptians. The spacious level and unclouded horizon of Chaldea afforded the utmost facilities for observing the celestial phenomena; and its inhabitants, enjoying the leisure afforded by a pastoral life, and stimulated by the vain desire of obtaining a knowledge of the future from the aspects of the stars, assiduously cultivated astronomy and astrology. By a long series of observations of eclipses, extending, according to the testimony of some authors, over nineteen centuries, or even a longer period, they had discovered the cycle of 223 lunations, or eighteen solar years, which, by bringing back the moon to nearly the same position with respect to her nodes, her perigee, and the sun, brings back the eclipses in the same order. This is supposed to be the period which they distinguished by the name of *Saros*. They had others, to which they gave the names of *Sossos* and *Neros;* but nothing positive is known with regard to their nature or extent. One thing only is certain, which is, that these Chaldaic periods, whatever they were, were founded on no theoretical knowledge of the celestial motions. They were purely empirical, detected by the comparison of recorded observations, and suppose neither theory nor science, unless, indeed, a simple arithmetical operation is to be considered as such; nor is there any reason to suppose that the Chaldeans employed any process of computation whatever in their predictions of eclipses. Having once established their cycle, they were in possession of a simple means of predicting all those which occurred in the course of it, with as great a degree of accuracy as they considered requisite.

The knowledge of these lunisolar periods among the Chaldeans is doubtless of great antiquity. Simplicius, the commentator of Aristotle, asserts that Callisthenes transmitted to Aristotle from Babylon a collection of observations of all the eclipses which had happened during the nineteen centuries that preceded the conquest of Alexander. This relation, however, is at variance with the accounts given by other historians. Epigenes, cited by Seneca and Pliny, who is supposed to have lived shortly before the time of Alexander, mentions observations of 730 years that had been found preserved on columns of brick. Ptolemy also makes mention of certain observations of eclipses that had been brought from Babylon, several of which he had calculated and verified; but the earliest of these ascends only to the year 720 before our era, or to the 26th of Nabonassar; and if either Hipparchus or himself had been acquainted with others of a more ancient date, they would doubtless have employed them in the determination of the mean motion of the moon. From this circumstance it appears probable that the Chaldeans had no observation sufficiently exact to be of any use to astronomy prior to the time of Nabonassar.

According to Apollonius of Myndus, the Chaldeans supposed the comets to be substances of the same nature as the planets; that they are visible only during a portion of their revolutions, and that they re-appear after certain intervals. But this statement, which argues some just notions respecting the celestial bodies, is contradicted by Epigenes, who himself studied among the Chaldeans, and who affirms, that instead of regarding the comets as subjected like the planets to the operation of eternal laws, they attributed their formation to vortices of inflamed matter, supposing them to have only a temporary existence, and to move in random directions through the fields of space. Diodorus says, that they regarded the world as eternal and imperishable, and held that its order is due, not to chance, but to a divine providence; that the planets, which have peculiar motions, announce future events by their various aspects and colours; that they portend rains, tempests, excessive heats; sometimes also the appearance of comets, eclipses, earthquakes, and, in short, whatever has a beneficial or hurtful influence on the fortunes of nations or individuals.

From the few facts that can be gleaned from the vague accounts given by ancient authors of the astronomy of the ancient Chaldeans, it may be inferred that their boasted science was confined to observations of the simplest and rudest kind, neither guided by theory, nor assisted by instruments; for, notwithstanding the assertion of Herodotus, it is doubtful if they were acquainted even with the gnomon, the simplest of all instruments for determining the obliquity of the ecliptic, the altitude of the pole, and the length of the tropical year. If to the knowledge of their lunisolar periods, the result of ages of observation, we add the notion of a spherical revolution about an inclined axis, and an idea of the principal circles of the sphere and the position of the poles, the sum will comprehend all that constituted the science of a people regarded by antiquity as having made the greatest progress in the science of the stars. Astronomy, however, owes some obligations to their humble labours. The observations which they recorded served to correct the theories that were afterwards imagined by the more brilliant genius of the Greeks, and thereby furnished some materials for the edifice of the world.

Egyptians. The Egyptians were in ancient times the rivals of the Chaldeans in the cultivation of astronomy; and although they have left behind them still fewer monuments of their labours, they have obtained, through the exaggerated statements of the Greeks, even a greater reputation. The Greeks acknowledge themselves indebted to the Egyptians for their science and civilisation; but regarding themselves likewise as descendants of that ancient people, they indulged their vain-glory in magnifying the accounts of the antiquity and knowledge of their supposed ancestors. It is not improbable that some traditional observations of the heavens, along with some arts indispensable to society even in its earliest stages, were carried into Europe by tribes migrating from the banks of the Nile; and it is certain that the early philosophers of Greece travelled into Egypt for the purpose of acquiring a more perfect knowledge of astronomy than could be obtained in their own country. But the facts from which it can be inferred that the Egyptians had much to communicate, are few and ill attested. They are also blended with so much absurdity and fable, that no accurate notions can be formed, from the accounts that have been transmitted to us, of the real advances which that people had made in astronomical science. The priests were the depositaries of the national knowledge; and they carefully concealed it from the vulgar by shrouding it in allegories, traces of which, it has been remarked, may be detected in the institutions even of the present day.

According to Diogenes Laertius, the Egyptians reckoned 48,853 years from Vulcan to Alexander, during which they had observed 373 eclipses of the sun, and 832 of the moon. These numbers in fact nearly express the relative proportion of the eclipses of the two luminaries; but the enormous length of the period altogether exceeds

History. the bounds of credibility; and it has been remarked that the same number of eclipses might have been observed within the more probable period of twelve or thirteen centuries. Supposing the numbers to be accurately stated, it will follow that, as the observations terminated with the conquest of Alexander, the Egyptians must have been in the habit of observing eclipses at least 1600 years before the commencement of our era. By attentively observing the heliacal rising of the star Sirius, to which they gave the name of Thaat, or Thoth (the Watch-Dog), because its appearance shortly preceded the overflow of the waters of the Nile, the Egyptians had discovered that the year consists of 365¼ days. This was their religious or sacred year. Their civil year consisted of only 365 days; consequently the sacrifices and feasts, which were regulated by it, successively corresponded to the different seasons. Instead of attempting to obviate this inconvenience by intercalation, they imposed an oath on their kings to maintain the use of the civil year, superstitiously imagining that each of the seasons would be blessed and rendered prosperous by enjoying in its turn the celebration of the feast of Isis. The difference between the lengths of the sacred and civil year suggested to them their famous sothic or canicular period of 1460 solar years, corresponding to 1461 civil years of 365 days, and which consequently brings back the months and festivals to the same seasons. Dion Cassius ascribes the week to the Egyptians, and says that they first dedicated a day to each of the planets; but it is sufficiently proved that this short cycle was in use among the Chinese and Indians from the remotest times, and was even known to the Druids of Gaul and Britain. It was more probably suggested to different nations by the phases of the moon. The Egyptians had likewise been attentive to the courses of the planets. Diodorus Siculus affirms that they could explain the phenomena of the stations and retrogradations; and Macrobius ascribes to them the knowledge of the real motions of Mercury and Venus, and says that they regarded these planets as satellites of the sun. This notion would do credit to their philosophy; but it is unfortunately not mentioned by any other author, and for this reason the testimony of Macrobius is suspected. The state of their practical astronomy may in some measure be inferred from the means they employed to determine the magnitude of the sun's apparent diameter. By comparing the time, observed by means of a clepsydra, which the sun takes to mount above the horizon at the equinox, with that in which he makes a complete revolution of the sky, they estimated his diameter at 28′ 48″. An observation of this kind is liable to great uncertainty; and as there is no evidence that the Egyptians possessed the slightest knowledge of spherical trigonometry, they would probably make no allowance for the obliquity of the equator to their horizon; and if this correction was left out of the calculation, as it probably was, their diameter, already too small, ought to have been still farther reduced, and to have amounted only to 24′ 42″. It has been conjectured by Goguet, that the obelisks of Egypt were intended to serve the purpose of gnomons; and this conjecture acquires some probability from their needle-shaped form, and the narrowness of their bases relatively to their heights. It has however been proved by MM. Jollois and Devilliers, in their description of Thebes, that the obelisks were connected with the walls of temples and palaces; a disposition which rendered them entirely unfit for the purposes of astronomical observation. Their summits were also of so unfavourable a form, that the Romans were obliged to surmount them with a ball in order to obtain a distinct and well-defined shadow. The pyramids have also been adduced as evidences of the early progress of astronomy among the Egyptians; for the faces of these stupendous masses are turned directly towards the four cardinal points, from which it is evident that the people by whom they were constructed were at least acquainted with the method of tracing a meridional line.

From this brief account it appears, that the only circumstances with which we are acquainted that imply the knowledge of astronomical methods among the Egyptians, are the length of the year, the doubtful discovery of the true motions of Mercury and Venus, and the position of the pyramids. The Chaldean observations were of use to Hipparchus and Ptolemy in the determination of some important elements; but those of the Egyptians exercised no influence whatever on the future progress of the science.

Phœnicians. The Phœnicians are also generally enumerated among the nations who cultivated astronomy at a very early period, though it does not appear, from any facts mentioned by ancient authors, that they addicted themselves to the observation of the heavens, or made any discoveries relative to the motions of the planets. That they excelled in the art of navigation is certain, from the commercial intercourse which they carried on with many places on the coasts of Africa and Spain, and in the principal islands of the Mediterranean; and it may readily be allowed that in their long voyages they would direct their course during the night by the circumpolar stars. If they had any speculative notions of astronomy, these were probably derived from the Chaldeans or Egyptians.

Chinese. In China, astronomy has been cultivated from the remotest ages, and always been considered as a science indispensably necessary to the civil government of the state. The Chinese boast of a series of eclipses, recorded in the annals of the nation, extending over a period of 3858 years, all of which, they pretend, were not only carefully observed, but calculated and figured previous to their occurrence. The same motives which led the Chaldeans and Egyptians to attend to the celestial phenomena, namely, the regulation and division of time, had equal influence among the Chinese; and we accordingly find the care of the calendar occupying the attention of their earliest princes. The emperor Fou-Hi, whose reign commenced about 2857 years before our era, is said to have assiduously studied the motions of the celestial bodies, and laboured to instruct his ignorant subjects in the mysteries of astronomy. But as they were yet in too rude a condition to be able to comprehend his theories, he was obliged to content himself with giving them a rule for the computation of time by means of the numbers 10 and 12, the combination of which produces the cycle of 60 years, which is the standard or unit from which they deduce their hours, days, and months. Tradition is silent with respect to the sources from which Fou-Hi derived his own knowledge. The Chinese attribute to him also the invention of arithmetic and music. In the year 2608 B. C., Hoang-Ti caused an observatory to be built, for the purpose of correcting the calendar, which had already fallen into great confusion, and appointed one set of astronomers to observe the course of the sun, another that of the moon, and a third that of the stars. It was then discovered that the twelve lunar months do not exactly correspond with a solar year; and that, in order to restore the coincidence, it was necessary to intercalate seven lunations in the space of nineteen years. If this fact rested on undoubted evidence, it would follow that the Chinese had anticipated the Greeks by 2000 years in the discovery of the Metonic cycle. The reign of Hoang-Ti is also rendered memorable by the institution of the *Mathematical Tribunal*, for promoting the science of

History. astronomy, and regularly predicting eclipses, to which an extraordinary importance has always been attached in China. The members of this celebrated tribunal were made responsible with their lives for the accuracy of their predictions, by a law of the empire, which ordained that, "whether the instant of the occurrence of any celestial phenomenon was erroneously assigned, or the phenomenon itself not foreseen and predicted, either negligence should be punished with death." In the reign of Tchong-Kang, the two mathematicians of the empire, Ho and Hi, were the victims of this absurd and sanguinary law; an eclipse having taken place which their skill had not enabled them to foresee.

The emperor Yao, who mounted the throne, according to the Chinese annals, about the year 2317 B. C., gave a new impulse to the study of astronomy, which had begun already to decline. He ordered his astronomers to observe with the utmost care the motions of the sun and moon, of the planets and the stars, and to determine the exact length of each of the four seasons. He sent Hi-Tchong to the east to observe the star situated at the point of the vernal equinox, Hi-Tchou to the south to examine that at the summer solstice, Ho-Tchong to the west, and Ho-Tchou to the north, to observe those situated respectively at the autumnal equinox and winter solstice. These docile observers found stars in the positions assigned by the emperor; but the extraordinary resemblance of their names imparts a fabulous air to the whole relation, and excites a very excusable incredulity even with regard to those statements which involve no improbability. To this emperor are attributed the Chinese division of the zodiac into 28 constellations, called the houses of the moon, and the severe laws already noticed in regard to the erroneous prediction of the celestial phenomena.

From the time of Yao the Chinese year consisted of $365\frac{1}{4}$ days. They also divided the circle into $365\frac{1}{4}$ degrees, so that the sun daily described in his orbit an arc of one Chinese degree. Their common lunar year consisted of $364\frac{543}{940}$ days; and by combining this number with $365\frac{1}{4}$, they formed the period of 4617 years, after which the sun and moon again occupy the same relative positions.

The earliest Chinese observations we are acquainted with, sufficiently precise to afford any result useful to astronomy, were made by Tcheou-Kong, whose reign commenced about the year 1100 before our era. Two of these observations are meridional altitudes of the sun, observed with great care at the village of Loyang, at the time of the summer and winter solstices. The obliquity of the ecliptic thus determined at that remote epoch is 23° 54′ 3·15″; a result which perfectly agrees with the theory of universal gravitation. Another observation, made about the same time, relates to the position of the winter solstice in the heavens; and it also corresponds to within a minute of a degree with the calculations of Laplace. Laplace considers this extraordinary conformity as an indubitable proof of the authenticity of those ancient observations.

The golden age of Chinese astronomy extended from the reign of Fou-Hi to the year 480 B. C.; that is, over a space of 2500 years. It is only, however, towards the latter part of this long period that the history of China becomes in any degree authentic; and the true date which must be assigned for the commencement of observations on which any reliance can be placed, is the year 722 B. C.; that is, 25 years posterior to the era of Nabonassar. From that period to the year 400 B. C. Confucius reckons a series of 36 eclipses, and of these 31 have been verified by modern astronomers. After this the science fell into great neglect, notwithstanding the inveterate tenacity with which the Chinese in general adhere to their ancient customs. The decline of their astronomy is ascribed, whether justly or not, to the barbarous policy of the emperor Tsin-Chi-Hong-Ti, who, in the year 221 B. C., ordered all the books to be destroyed, excepting those only which related to agriculture, medicine, and astrology, the only sciences which he considered as being of any use to mankind. His fury, it is true, was principally directed against those of Confucius, the stern morality of which he felt to be a censure on his own profligacy; but those of science and astronomy were included in the general destruction. In this manner, it is said, the precious mass of astronomical observations and precepts which had been accumulating for ages was irretrievably lost.

Lieou-Pang, the successor of Tsin-Chi-Hong, endeavoured to repair the disaster, by re-establishing the tribunal of the mathematics, and ordering a new series of observations to be undertaken. About the year 104 B. C. the astronomer Sse-Ma-Tsien gave some precepts for the calculation of eclipses, the motions of the planets, and the syzygies. He employed instruments of copper, the nature and construction of which are however not very well understood, for measuring the extent of the 28 zodiacal constellations; and he observed the meridional altitudes of the sun, by means of a gnomon 8 feet high. The differences of right ascensions, and the intervals between the risings, settings, and culminations of the stars, were measured by clepsydræ. It would appear that after this period astronomical observations continued for some time to be made in China with considerable regularity. In the 164th year of our era the astronomer Tchang-Heng constructed armillary spheres and a celestial globe. He also formed a catalogue of stars, which is said to have contained 2500, but without either latitudes or longitudes; a circumstance which gives us a very unfavourable idea of the state of practical astronomy at that time. About the eighth century of our era, all knowledge of the science seems to have been again lost. The predictions were erroneous; and the Chinese witnessed, with superstitious terror, eclipses of which their astronomers had given them no intimation. This induced the emperor Hieng-Tsong to call to his court the astronomer Y-Hang, by whose indefatigable activity a reform was speedily effected. With a view to determine the situations of the principal places of the empire, this astronomer constructed gnomons, spheres, astrolabes, quadrants, and other instruments; and sent one company of mathematicians to the south, and another to the north, with directions to observe daily the altitudes of the sun and the polar star. The latitudes of the cities were determined by observing the shadow of the gnomon, and the longitudes by eclipses of the moon. Y-Hang had the mortification of announcing two eclipses which did not take place. On these occasions he alleged the usual excuse, namely, that his calculus was not in error, but that the celestial bodies had deviated from their ordinary courses out of respect to the virtues of the emperor. The fate of Ho and Hi had probably suggested to the Chinese astronomers this ingenious mode of disarming the emperor's resentment by flattering his vanity.

On considering attentively the accounts which have been given of the Chinese astronomy, we find that it consisted only in the practice of observations which led to nothing more than the knowledge of a few isolated facts. The missionaries who were sent out by the Jesuits about the end of the seventeenth century, to whom we are indebted for what is known of the early history

of China, either seduced by some appearances of truth, or thinking it prudent to conciliate the people whom they were attempting to convert, adopted their marvellous relations regarding the antiquity of their science, and spread them over Europe. As the history of the nation begins to become more authentic, their astronomy shrinks into its real but insignificant dimensions. Superstitiously attached to their ancient usages, and blindly adopting the habits of their ancestors, the Chinese continued to observe the heavens from century to century without making the slightest advances in theoretical knowledge. In later times they have adopted many improvements, for which they are entirely indebted to foreigners. During the time of the caliphs many Mahometans passed into China, carrying with them the astronomical methods and knowledge of the Arabians. The missionaries introduced the science of Europe; and the most that can be said in praise of the Chinese is, that their government sometimes relaxed so far its spirit of jealousy and exclusion, as to afford protection to these strangers, adopt their arts, and place them at the head of the mathematical tribunal.

The astronomy of the Indians forms one of the most curious problems which the history of science presents to the consideration of the learned, and one which, notwithstanding the numerous dissertations to which it has given rise, still continues involved in great uncertainty. Of the science of the ancient nations, of which we have already spoken, the accounts which have come down to our times are founded on conjecture and tradition; for few monuments remain to confirm or confute the glowing descriptions which authors have given of its high antiquity and great perfection. But the claims of the Indians rest on more solid foundations. We are in possession of the tables from which they compute the eclipses and places of the planets, and of the methods by which they effect the computation: we have, in short, an Indian astronomy committed to writing, which represents the celestial phenomena with considerable exactness, and which, therefore, could only be produced by a people far advanced in science. But the difficulty of the problem consists in determining the sources from which this science originated, and the epoch of its existence; whether it was created by the people who now blindly follow its precepts without understanding its principles, or was communicated to them by another race of a bolder and more original genius, through channels with which we are unacquainted. Some authors regard India as the cradle of all the sciences, particularly of astronomy, which they suppose to have been cultivated there from the remotest ages; others date the origin of the Indian astronomy from the period when Pythagoras travelled into that country, and carried thither the arts and sciences of the Greeks; a third opinion is, that astronomy was conveyed to India by the Arabians in the ninth century of our era, and that the Brahmins are only entitled to the humble merit of adapting the rules and practices of that people to their own peculiar methods of calculation. We shall endeavour to describe very briefly the existing monuments of the Indian astronomy, which furnish the only data from which a rational conjecture can be formed relative to its antiquity and precision.

We possess four different sets of tables of Indian astronomy. The first which were known in Europe were brought from Siam by La Loubère, who had resided in that country as ambassador from Louis XIV. They were communicated by him to the celebrated Cassini, who, notwithstanding the difficulties arising from the complicated and useless operations which they directed, succeeded in detecting the principles on which they were constructed, and in explaining their use and signification. The date of these tables corresponds to the 21st of March in the year 638 of our era. They suppose two species of years, the solar tropical year, which they make to consist of 365 days 5 hours 50 min. and 4 sec., and the solar anomalistic year, that is, the period in which the sun returns to its apogee, which they estimate at 365 days 6 hours 12 min. 36 sec. This determination of the length of the solar year is too great only by 1 min. 15 sec. By means of the same tables the longitudes of the sun and moon are determined with considerable accuracy. They contain a correction for the sun's mean place, which corresponds to the equation of the centre. At 90° from the apogee, where the inequality of the sun's motion is greatest, they estimate the requisite correction at 2° 12′, which is about 16′ too great. This determination deserves to be particularly remarked, because, on account of a secular inequality of the eccentricity of the sun's orbit, there was once a time when the greatest value of the equation of the centre was nearly 2° 12′; and this fact is adduced as a proof of the remote antiquity of the observations from which the tables in question have been constructed. These tables suppose the apogee to retain always the same position relatively to the fixed stars; in reality it advances or gains on the stars about 10″ annually; but the supposition is still much nearer the truth than in the system of Ptolemy, where the apogee is supposed to be absolutely at rest with regard to the plane of the sun's orbit, and consequently to fall back among the stars by the whole quantity of the precession of the equinoxes, or about 50″ annually. With regard to the motions of the moon, they are deduced from a period of 19 years, in which are comprehended nearly 235 lunations; so that the cycle of Meton appears to have been known in Siam as well as in China. The moon's apogee is supposed to have been in the beginning of the movable zodiac 621 days after the epoch of the 21st of March 638, and to make an entire revolution in the heavens in the space of 3232 days. The first of these suppositions agrees with Mayer's tables to within a degree, and the second differs from them only by 11 hours 14 min. 31 sec. They contain only one correction for the two principal inequalities of the moon's motion, the equation of the centre and the evection.

A second set of Indian tables was sent from Chrisnabouram, a town in the Carnatic, by Father Du Champ, to De Lisle, about the year 1750. They are fifteen in number. They give the mean motions of the sun, moon, and planets; equations of the centre for the sun and moon; and two corrections for each of the planets, one of which corresponds to the apparent, the other to the real inequality. The epoch of these tables is not so ancient as that of the former. It corresponds to the 10th of March, at sunrise, in the year 1491 of our era, when the sun and moon were in conjunction.

A third set of astronomical tables was sent from India by Father Patonillet, and received by De Lisle about the same time with those of Chrisnabouram. These have not the name of any particular place affixed to them; but being calculated for the latitude of 16° 16′, Bailly thinks it probable that they came from Narsapour. Their epoch is midnight, between the 17th and 18th of March 1569.

The fourth and last set of Indian tables which we possess have been published in the Memoirs of the Academy of Sciences. They were communicated by a learned Brahmin of Tirvalore, a small town on the Coromandel coast, to the French astronomer Legentil, who had gone to India to observe the transit of Venus in 1769. The tables

History. of Tirvalore, though somewhat different in form, present many points of resemblance with those formerly known in Europe. They suppose the same length of the year, the same inequalities of the sun and moon, and they are adapted nearly to the same meridian. But while they correspond with the other tables in these elements, they differ from them greatly in the antiquity of their epoch, which goes back to the famous era of the Calyougham, that is, the beginning of the year 3102 before Christ.

Now, the only question to be determined with regard to the antiquity of the Indian astronomy is, whether this epoch is real or fictitious; that is, whether the state of the heavens at the commencement of the Calyougham, as assumed in these tables, was actually determined by observation, or computed backwards from observations of more modern date. The solution to this question can only be obtained from the internal evidence afforded by the tables themselves; by examining whether the elements and precepts which they furnish are of sufficient accuracy to enable the places of the sun, moon, and planets to be calculated through a period of 44 centuries, without involving errors which the refined accuracy of the modern tables furnishes the means of detecting. A comparison of the Indian with the modern tables has been made at great length by Bailly, who imagines that he finds ample evidence of the reality of the era in question, and of the existence of an astronomy prior to that period, hardly yielding in accuracy to that which modern science has built on the theory of universal gravitation. The theory of Bailly has been adopted, and put forth with additional clearness and evidence, by the late Professor Playfair. One of the principal arguments which these illustrious authors bring forward in support of it is founded on the longitudes of the sun and moon. The mean place of the moon at the commencement of the Calyougham, that is, at midnight, between the 17th and 18th of February 3102 B. C., is stated by the Indian tables to be 306°. Her mean place, computed from Mayer's tables, without taking into account the acceleration, with which the Indians in the 15th century were of course unacquainted, is 300° 51′ 16″. Hence there would be a discrepancy of 5° 8′ 44″. But, according to the theory and last tables of Laplace, the moon, in virtue of the acceleration of her mean motion, has passed over an arc of very nearly 6° more than she would have done had her mean motion continued uniform from the period of the Calyougham to the date of Mayer's tables. This added to 300° 51′ 16″ gives 306° 51′ 16″ for the mean longitude of the moon at the epoch of the Calyougham, differing from the Indian determination by only 51′ 16″. Now, it is argued that this is a degree of accuracy which could have been reached only by actual observation, especially since, if the tables had been computed backwards, the error arising from the acceleration alone would have amounted to more than 5°. Bailly computes the place of the moon at the same epoch, from all the tables, Greek and Arabian, to which the Indians can be supposed to have had access, and the discrepancies are so great as to render his conclusion almost inevitable, that the Indian tables could not possibly have been drawn from such sources. The tables of Ptolemy make the moon's longitude at that time 11° 52′ 7″ greater than the Indian tables; and those of Ulugh-Beigh, constructed at Samarcand in 1437, give a difference of 6° also in excess.

Similar results are obtained from the consideration of other elements. According to the tables of Tirvalore, the tropical year consists of 365 days 5 hours 50 min. 35. sec. Lacaille makes it 365 days 5 hours 48 min. 49 sec. The difference is 1 min. 46 sec. Now the tropical year, being affected by the precession of the equinoxes, is subject to a secular inequality, which, according to the theory of Lagrange, renders it actually shorter by 40·5 sec. at the present time than it was at the commencement of the Calyougham. The error of the Indian tables is thus reduced to 1 min. 5·5 sec. In like manner, the obliquity of the ecliptic, which has been gradually diminishing during a great number of centuries, is supposed in the Indian tables to be greater than it is now found to be by observation. The Brahmins estimate it at 24°. The formula of Lagrange makes the variation, in 4800 years, amount to 22′ 32″. This therefore must be added to its obliquity in 1700, that is, to 23° 28′ 41″, in order to have the true obliquity at the commencement of the Calyougham. The sum is 23° 51′ 13″, and falls short of the Indian determination by 8′ 47″. We shall mention only another element, the equation of the centre of the sun. Bailly calculates that, according to the theory of Lagrange, the equation of the sun's centre, at the epoch of the tables, was 2° 6′ 28″. The Indians make it 2° 10′ 32″. The difference is only about 4′, and incomparably less than could have resulted from calculation by any methods which we can suppose the Indians to have possessed.

These arguments, it must be admitted, are exceedingly specious, but they are not by any means convincing. Even with the best modern tables we could not, as Bailly himself acknowledges, answer for the accuracy of the places of the sun and moon computed for so remote an epoch. The corrections for the secular inequalities amount in that long period to considerable quantities; and these corrections are deduced by theory from elements with respect to which there exists great uncertainty. And if we cannot be sure of the true places by computing backwards from our own tables, with what degree of confidence can we pronounce upon the accuracy of the places assigned in the tables of the Indians? It may be said that comparisons of this kind can never be supposed to give results perfectly alike. Granted: but if the discrepancies are such that the lapse of a thousand years more or less is required to establish a rigorous conformity, what becomes of the famous epoch of the Calyougham? Some of the elements of the Indian tables could not have the values assigned to them but at a long period before that epoch. In order to find their equation of the sun's centre, for example, it is necessary, according to the results of modern theory, to go back to 6000 years before our era. The argument, therefore, proves too much, and is consequently inconclusive. The different sets of tables of which we have spoken are closely allied with each other, and the most probable supposition is, that they are all derived from those of Chrisnabouram, of which the epoch is 1491. At that era the Indians were acquainted with the instruments, the geometry, and the researches of the Arabians and Greeks. Through this channel the tables seem to have come into their possession. The Brahmins adapted them to their own particular methods of computation, and threw back their epoch to the period when, according to these tables, all the planets were in conjunction with the sun. Every circumstance connected with the science of the Indians conspires to give us the humblest ideas of its value. Their methods of computation are encumbered with the unnecessary multiplications and divisions of enormous numbers, endless additions, subtractions, and reductions, for the purpose of obtaining numbers which could be put into technical verses, and even adapted to songs; so that the astronomer might be enabled to effect his calculations from memory alone, without its being necessary to have

History. recourse to tables or books. But simple and rude as these methods are, if they were really invented by the Brahmins, the science of that people must have greatly retrograded; for at present they merely follow a blind routine, utterly ignorant of theory, or the principles on which their processes are founded. Their astronomy, whether of ancient or recent origin, has produced no effect whatever on that of Europe; it has no filiation or connection with the science of the present day, and therefore has no other claim on our attention than such as may result from motives of mere curiosity.[1]

Astronomy of the Greeks.

The origin of astronomy in Greece, as in other early nations, ascends beyond the period of authentic history, and is concealed amidst the fables and traditions of the remotest times. During the darkness of the heroic ages some gleams of an acquaintance with the motions of the stars occasionally burst forth; and some traces appear of astronomical observations, probably derived from Egypt, the country which also furnished Greece with its gods and its arts. The Greeks seem to have divided the heavens into constellations about 13 or 14 centuries before the Christian era; for the sphere of Eudoxus, which is probably one of the fruits of the famous voyage of the Argonauts, must be referred to that period. Their early attention to the appearances of the heavens is sufficiently attested by their mythological fables, the greater part of which are only allegories of the celestial motions, and of the operations of nature. The lively fancy and brilliant imagination of this ingenious people strewed flowers in the most rugged paths, and spread agreeable images over the driest and most uninviting subjects: hence the sky was quickly covered with legends of the loves and exploits of gods and heroes. It would be foreign to our present purpose to enter into an enumeration of these fables, or attempt to trace their connection with the first dawnings of astronomy: we shall content ourselves with barely alluding to Uranus, to Atlas and his son Hesperus, who gave his name to the planet Venus; also to his daughters the Atlantides, from whom the Pleiades received their appellation; to Endymion, who, on the summit of Mount Latmos, held nocturnal converse with the chaste Diana; to Hercules; and Chiron the centaur, who taught men the use of the constellations; Musæus, who imagined the figures of men and animals which cover the celestial sphere; Orpheus and Linus, who explained the theogonies; Atreus, from whose banquet the sun fled back with horror; and Tiresias, who was struck blind for having witnessed some secret of the gods.

Thales born 640 B.C. The true foundations of Grecian science were laid by Thales, who was born at Miletus 640 years before our era. He was descended from an illustrious family, which had formerly reigned in Phœnicia, and inherited an ample fortune, which he expended in collecting the expiring embers of oriental science. Instigated by the love of knowledge, he travelled first into Crete, and afterwards into Egypt, where he was initiated into the mysteries of the priests, to whom, in return, he is said to have taught the method of measuring the height of the pyramids by comparing their shadows with those of known objects. Returned to his own country, he publicly taught the truths he had collected during his travels, and formed a sect which has been distinguished by the title of the *Ionian School.* His doctrines regarding astronomy contain a few truths which do honour to his sagacity and observation, though they are mixed with much error and absurdity. He taught that the stars are formed of fire; that the moon receives her light from the sun, and is invisible at her conjunctions, because she is hid in the sun's rays. He also taught the sphericity of the earth, which he placed at the centre of the world. He divided the sphere into five zones, by the arctic and antarctic circles, and the two tropics; and held that the equator is cut obliquely by the ecliptic, and perpendicularly by the meridian. He is also said to have observed eclipses; and Herodotus relates that he predicted the famous one which put a stop to the war between the Medes and the Lydians. It does not appear, however, that he ventured to assign either the day or the month of the eclipse, so that his prediction must have been confined to the year. According to Callimachus, he determined the positions of the stars which form the Lesser Bear, by which the Phœnicians guided themselves in their voyages. It is difficult, however, to conceive how Thales, unacquainted with instruments, could determine the positions of stars with so much accuracy as to render any essential assistance to the navigator. It is probable that he only pointed out the configuration, and some of the more brilliant stars of that constellation, among which he might remark that which is nearest the pole of the world.

Anaximander, born 610 B.C. Thales was succeeded by Anaximander, to whom is also attributed the invention of the sphere, and the knowledge of the zodiac. According to Diogenes Laertius, he supposed, like his master Thales, the earth to be spherical, and placed at the centre of the universe; but Plutarch ascribes to him the less philosophical opinion of its resemblance to a column. He supposed the sun to be of equal magnitude with the earth. He invented the gnomon, and placed one at Lacedæmon to observe the solstices and equinoxes. But the circumstance which does most honour to Anaximander, and which entitles him to the gratitude of posterity, is the invention of geographical charts. He is said also to have believed in the plurality of worlds,—a sublime idea, which was adopted by almost every succeeding philosopher of Greece.

Anaximenes, born 530 B.C. Anaximenes succeeded Anaximander in the Ionian school, and maintained nearly the same doctrines. Pliny says he was the first who taught the art of constructing dials,—an invention which, as we have just seen, has also been ascribed to Anaximander. These two philosophers probably revived the knowledge of an instrument the use of which had been forgotten amidst the general rudeness and ignorance of their countrymen. Before their time the Greeks only marked the divisions of the day by the different lengths of the sun's shadow.

Anaxagoras, born 500 B.C. Anaxagoras was the disciple and successor of Anaximenes. If this philosopher really entertained the ridiculous opinions ascribed to him by Plutarch, the Ionian school must rather have retrograded than advanced in sound philosophy from the time of Thales. He is said to have believed that the sun is a mass of red-hot iron, or of heated stone, somewhat bigger than the Peloponnesus,—that the heaven is a vault of stones, which is prevented from tumbling only by the rapidity of its circular motion,—and that the sun is prevented from advancing beyond the tropics by a thick and dense atmosphere, which forces

[1] For an account of the Indian astronomy, see Bailly, *Astronomie Indienne;* also a Memoir by Professor Playfair, in the *Edinburgh Transactions*, vol ii., or in the 3d volume of his Works; and the Papers of Jones, Bently, and Davis, in the *Calcutta Memoirs.* The theory of Bailly is most satisfactorily refuted by Delambre. See his *Histoire de l'Astronomie Ancienne*, tom. i.

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him to retrace his course. These absurd notions are probably greatly exaggerated; but it does not appear that Anaxagoras contributed much to extend the knowledge of the heavens. A melancholy interest is, however, excited in his behalf, on account of the persecution which he suffered in consequence of his liberal opinions and his disregard for the superstitious notions of his age. Having shown the reason of the eclipses of the moon, he was accused of ascribing to natural causes the attributes and power of the gods. Having taught the existence of only one God, he was accused of impiety and treason towards his country. Sentence of death was pronounced on the philosopher and all his family; and it required the powerful interest of his friend and disciple Pericles to obtain a commutation of this iniquitous sentence into one of perpetual banishment.

Pythagoras, born 580 B.C.

While the Ionian sect was so successfully employed in cultivating and propagating a knowledge of nature in Greece, another, still more celebrated, was founded in Italy by Pythagoras. This renowned philosopher was in early youth a disciple of Thales. In quest of knowledge, which in those days could only be obtained by visiting the sages of foreign lands, he travelled into Egypt, Phœnicia, Chaldea, and India, where his memory is said still to subsist. Through the favour of Amadis, king of Egypt, to whom he was recommended by Polycrates, the tyrant of Samos, he was admitted into the sacred college at Memphis, though with great reluctance on the part of the priests. The severe ordeal through which these charlatans compelled him to pass, before they would consent to initiate him into their mysteries, was sufficient to have deterred the most courageous votary of knowledge; and Pythagoras was probably the only stranger who ever succeeded in fully exploring their secrets. After an absence of thirty years he returned to Greece, and began to give instructions in his native island of Samos. Soon after, he passed over to the Grecian colony established at Tarentum in Italy, and settled at Crotona, where he speedily acquired a splendid reputation. He was the first who assumed the modest title of *philosopher*, or lover of wisdom: formerly those who devoted themselves to the acquisition of learning were called *sophists* or *sages*.

Pythagoras is said to have acquired in Egypt the knowledge of the obliquity of the ecliptic, and that of the identity of the morning and evening stars. What he chiefly deserves to be commemorated for in the history of astronomy, is his philosophical doctrine regarding the motion of the earth. He taught publicly that the earth is placed at the centre of the universe; but among his chosen disciples he propagated the doctrine that the sun occupies the centre of the planetary world, and that the earth is a planet circulating about the sun. This system, which still retains his name, being called the old or Pythagorean system of the universe, is that which was revived by Copernicus. It is, however, only just to the memory of this last mentioned great man to observe, that there is a vast difference between the bare statement of the possibility of a fact, and the demonstration of its existence by irrefragable arguments. Pythagoras having remarked the relation which subsists between the tone of a musical chord and the rapidity of its vibration, was led by analogy to extend the same relation to the planets, and to suppose that they emit sounds proportional to their respective distances, and form a celestial concert too melodious to affect the gross organs of mankind. Another fancy into which he was led by his passion for analogies, was the application of the five geometrical solids to the elements of the world. The cube symbolically represented the earth; the pyramid, fire; the octaedron, air; the icosaedron, or twenty-sided figure, water; and the dodecaedron, or figure with twelve faces, the exterior sphere of the universe. Pythagoras left no writings; and it is doubtful whether he really entertained many of the opinions and reveries which have usually been ascribed to him.

Philolaus.

Philolaus of Crotona, a disciple of Pythagoras, embraced the doctrine of his master with regard to the revolution of the earth about the sun. He supposed the sun to be a disk of glass which reflects the light of the world. He made the lunar month consist of $29\frac{1}{2}$ days, the lunar year of 354 days, and the solar year of $365\frac{1}{2}$ days.

Nicetas.

Nicetas of Syracuse seems to have been the first who openly taught the Pythagorean system of the universe. Cicero, on the authority of Theophrastus, the ancient historian of astronomy, gives him the credit of maintaining that the apparent motion of the stars arises from the diurnal motion of the earth about its axis;[1] but this rational doctrine seems to have been first broached by Heraclides of Pontus, and Ecphantus, a disciple of Pythagoras.

Metonic cycle, 433 B.C.

The introduction of the Metonic cycle forms an era in the history of the early astronomy of Greece. The Chaldeans, as we have already stated, established several luni-solar periods; and the difficulty of reconciling the motions of the sun and moon, or of assigning a period at the end of which these two luminaries again occupy the same positions relatively to the stars, had long embarrassed those who had the care of regulating the festivals. Meton and Euctemon had the honour of first obviating this difficulty, at least for a time; for the motions of the sun and moon being incommensurable, no period can be assigned which will bring them back to precisely the same situations. These two astronomers formed a cycle of nineteen lunar years, twelve of which contained each 12 lunations, and the seven others each 13, which they intercalated among the former. It had long been known that the synodic month consisted of $29\frac{1}{2}$ days nearly; and in order to avoid the fraction, it had been usual to make the twelve synodic months, which compose the solar year, to consist of 29 and 30 days alternately; the former being called *deficient* and the latter *full* months. Meton made his period to consist of 125 full and 110 deficient months, which gives 6940 days for the 235 lunations, and is nearly equal to 19 solar years. This cycle commenced on the 16th of July in the year 433 B. C. It was received with acclamation by the people assembled at the Olympic games, and adopted in all the cities and colonies of Greece. It was also engraved in golden letters on tables of brass, whence it received the appellation of the *golden number*, and has been the basis of the calendars of all the nations of modern Europe. It is still in ecclesiastical use, with such modifications as time has rendered necessary.

Eudoxus, 370 B.C.

Eudoxus of Cnidus, about the year 370 B. C., obtained great reputation as an astronomer. According to Pliny, he introduced the year of $365\frac{1}{4}$ days into Greece. Archimedes says that he supposed the diameter of the sun to be nine times greater than that of the moon, which shows that he had in some degree overcome the illusions

[1] "Nicetas Syracusius, ut ait Theophrastus, cœlum, solem, lunam, stellas, supera denique omnia, stare censet; neque, præter terram, rem ullam in mundo moveri; quæ cum circum axem se summa celeritate convertat et torqueat, eadem effici omnia, quasi, stante terra, cœlum moveretur." (Cicero, *Acad. Quæst.: Opera*, tom. iv. p. 39, edit. Bipont.) Copernicus himself could not have stated the doctrine with greater precision.

History. of sense. The titles of three of his works have been preserved—the *Period or Circumference of the Earth*, the *Phenomena*, and the *Mirror*. His observatory was still standing at Cnidus in the time of Strabo. His memory deserves to be honoured for the contempt which he evinced for the Chaldean predictions, and for having contributed to separate true astronomy from the reveries of judicial astrology. Eudoxus seems to have been the first who attempted to give a mechanical explanation of the apparent motions of the planets. He supposed each planet to occupy a particular part of the heavens, and that the path which it describes is determined by the combined motion of several spheres performed in different directions. The sun and moon had each three spheres; one revolving round an axis which passes through the poles of the world, and which occasions the diurnal motion; a second revolving round the poles of the ecliptic, in a contrary direction, and causing the annual and monthly revolutions; the third revolving in a direction perpendicular to the first, and causing the changes of declination. Each of the planets had a fourth sphere to explain the stations and retrogradations. As new inequalities and motions were discovered, new spheres were added, till the machinery became so complicated as to be altogether unintelligible.

Plato. Although Plato can hardly be cited as an astronomer, yet the progress of the science was accelerated by means of the lights struck out by his sublime and penetrating genius. He seems to have had just notions of the causes of eclipses; and he imagined that the celestial bodies originally moved in straight lines, but that gravity altered their directions, and compelled them to move in curves. He proposed to astronomers the problem of representing the courses of the stars and planets by circular and regular motions. Geometry was assiduously cultivated in the school of Plato; and on this account he claims a distinguished place among the promoters of true astronomy.

Aristotle, born 384, died 322, B.C. Astronomy is also under some obligations to Aristotle. In a treatise which he composed on this science, he recorded a number of observations which he had made; and, among others, mentions an eclipse of Mars by the moon, and the occultation of a star in the constellation Gemini by the planet Jupiter. As such phenomena are of rare occurrence, their observation proves that he had paid considerable attention to the planetary motions.

A great number of astronomers about this time appear on the stage, whose labours and observations prepared the way for the reformation of the science which was shortly after effected by Hipparchus. Helicon of Cizicene is renowned for the prediction of an eclipse, which took place, as Plutarch affirms, at the time announced. History records the names of only three individuals in ancient Greece who predicted eclipses, Thales, Helicon, and Eudemus. Eudemus composed a history of astronomy, a fragment of which, consisting of only a few lines, is preserved by Fabricius in the *Bibliotheca Græca*. In this it is mentioned that the axes of the ecliptic and equator are separated from each other by the side of a pentedecagon, which is equivalent to saying that they contain an angle of 24°. This is the first value which we find assigned by the Greeks to the obliquity of the ecliptic. It is given in round numbers, and may easily be supposed to contain an error of a quarter of a degree.

Calippus. Calippus is celebrated for the period which he formed of four Metonic cycles. Having observed, by means of an eclipse of the moon which took place about six years before the death of Alexander, that the Metonic cycle contained an error of a fourth of a day, he introduced the period of 940 lunations, containing four Metonic cycles, diminished by one day. He likewise formed a collection of observations on the heliacal risings of the planets. Theophrastus wrote a history of astronomy, and supposed the milky way to be produced by the imperfect junction of the two hemispheres, which allowed the light to penetrate from the firmament beyond. Autolycus of Pitaneas wrote two books, one on the movable sphere, the other on the risings and settings of the stars. These are the most ancient of the astronomical works of the Greeks which have come down to our times.

Theophrastus. Autolycus.

Pytheas of Marseilles, about the time of Alexander the Great, determined the length of the solstitial shadows in various countries by means of the gnomon. He found the shadows equal at Marseilles and Byzantium—a circumstance which does not give a favourable idea of the accuracy of his observations, inasmuch as the difference of the latitudes of the two places amounts to $2\frac{1}{4}$ degrees. The observation is, however, interesting, as it is the most ancient of the kind which has been preserved after that of Tcheou-Kong, and as it confirms the successive diminution of the obliquity of the ecliptic. Pytheas undertook several voyages for the purpose of obtaining geographical and astronomical information, and advanced northwards as far as Iceland. His relations have been treated as fabulous by Strabo and Polybius, but the accuracy of the greater number of them has been confirmed by modern observation and experience. He was the first who distinguished the climates by the different lengths of the days and nights.

Pytheas.

Astronomy in the School of Alexandria.

In the history of the various sects which have hitherto come under our review, we meet only with some useful remarks, with numerous hypotheses and conjectures, but with scarcely any appearance of regular and connected science. Up to this date the astronomical knowledge of the Greeks was confined to a few facts, the discovery of which implies no theory, and scarcely the aid even of the simplest instruments. The order and arrangement of the planets, the causes of eclipses, the identity of the morning and evening stars, the approximate length of the year, that of the lunar month, the obliquity of the ecliptic, and the cycles of Meton and Calippus, were almost the sole results of their astronomical speculations. In the Alexandrian school we meet for the first time with regular and systematic observations. We there find angular distances measured with appropriate instruments, and calculations made according to the rules of trigonometry.

After the premature death of Alexander, his principal generals shared among themselves his magnificent conquests, and Egypt fell to the lot of Ptolemy Soter. This prince was distinguished by an ardent love of science, and a desire to promote every species of liberal knowledge. He accordingly invited to his court, which he had established at Alexandria, the most eminent philosophers of Greece, and fixed them there by his liberality and munificent protection. His son, Ptolemy Philadelphus, who inherited his throne, also inherited his genius and love of science and learning. A superb edifice, styled the *Museum*, was assigned to the use of the men of science whom he had attracted to his capital, to which he also added an observatory, and the famous library, which had been collected with great care and at a vast expense by Demetrius Phalerius. The prince took great delight in the Museum; he visited it frequently, entered into familiar conversation with its inmates on the subject of their various pursuits, and by his own example stimulated their

History. zeal and encouraged their inquiries. This noble institution, which survived all the vicissitudes of nine centuries, was the means of conferring incalculable benefits on the human race; and the name of its founder, Ptolemy Philadelphus, will be gratefully remembered while science and learning occupy a place in the estimation of mankind.

Aristillus and Timocharis, 300 B. C.

The first astronomers of the Alexandrian school were Aristillus and Timocharis, who flourished under the first Ptolemy, about 300 years before Christ. The chief object of their labours was the determination of the relative positions of the principal stars of the zodiac, instead of merely announcing their risings and settings, as had been the practice of the orientals and the ancient Greeks. The observations of these two astronomers conducted Hipparchus to the important discovery of the precession of the equinoxes, and served as the basis of the theory which Ptolemy, some centuries afterwards, gave of that phenomenon.

Aristarchus, B. C. 281.

Aristarchus of Samos, the next in order of the Alexandrian astronomers, composed a treatise on the *Magnitudes* and *Distances* of the sun and moon, which has been preserved to our times. In this treatise he describes an ingenious method which he employed to obtain the relative distances of the two luminaries. At the instant when the moon is dichotomized, that is, when the exact half of her disk appears to a spectator on the earth to be illuminated by the sun's light, the visual ray passing from the centre of the moon to the eye of the observer is perpendicular to the line which joins the centre of the moon and sun. At that instant, therefore, he measured the angular distance of the two bodies, and finding it to be 87 degrees, he concluded, by the resolution of a right-angled triangle, that the distance of the sun is between eighteen and nineteen times greater than that of the moon. This method is perfectly correct in theory, but it is difficult to be assured of the exact instant of the moon's dichotomy, and in an angle of such magnitude a very small error greatly affects the result. The error of Aristarchus is very considerable, the true angle being about 87° 50′. The estimated distance of the sun is by consequence far too small; yet the determination, faulty as it was, contributed to expand greatly the existing notions relative to the boundaries of the universe, for the Pythagoreans had taught that the sun is only three, or at most three and a half times more distant than the moon. Another delicate observation made by Aristarchus was that of the magnitude of the sun's diameter, which, as we learn from Archimedes, he determined to be the 720th part of the circumference of the circle which the sun describes in his diurnal revolution. This estimate is not very far from the truth, and the observation is by no means an easy one. He embraced the doctrine of Pythagoras respecting the earth's motion, and appears to have entertained juster notions than any of the astronomers who preceded him, on the magnitude and extent of the universe. The treatise on the *Magnitudes* and *Distances* is published in the third volume of the works of Dr Wallis, with a Latin translation by Commandine, and some notes.

Eratosthenes, born 276 B. C.

Eratosthenes, the successor of Aristarchus, was a native of Cyrene, and invited to Alexandria by Ptolemy Evergetes, who appointed him keeper of the royal library. He is supposed to have been the inventor of armillary spheres, a species of instrument extensively used by the ancient astronomers. By means of an instrument of this kind he observed the distance between the tropics to be to the whole circumference of a great circle as 11 to 83; a ratio equivalent to 47° 42′ 39″, half of which gives 23° 51′ 19·5″ for the obliquity of the ecliptic. This is a very important observation, and confirms the gradual diminution of the obliquity as indicated by theory. Eratosthenes is celebrated for being the first who attempted, on correct principles, to determine the magnitude of the earth. Having remarked, by some means with which we are unacquainted, that Syene, the most southern of the cities of ancient Egypt, is situated nearly on the same meridian with Alexandria, he conceived the idea of determining the amplitude of the celestial arch intercepted between the zeniths of the two places, and of measuring at the same time their distance on the ground; operations which would afford data for the determination of the whole length of the terrestrial meridian. Syene was known to be situated exactly under the tropic; for at the summer solstice the gnomon had no shadow, and the sun's rays illumined the bottom of a deep well in that city. On the day of the solstice he found the meridional distance of the sun from the zenith of Alexandria to be 7° 12′, or a fiftieth part of the circumference. It had also been ascertained by the *bematists* or surveyors of Alexander and the Ptolemies, that the itinerary distance between Alexandria and Syene was 5000 stadia; therefore $5000 \times 50 = 250{,}000$ stadia form the circumference of a great circle of the earth, or the length of the terrestrial meridian. Unfortunately, on account of the uncertainty respecting the length of the stadium here employed, we possess no means of estimating the degree of approximation afforded by this rude though ingenious attempt; but the idea does immortal honour to Eratosthenes, and the moderns have added nothing to his method: their better success is owing solely to the progress of the arts and the perfection of astronomical instruments.

About this time the science of astronomy was enriched by the discoveries of some of the distinguished geometricians whose labours have so greatly extended the glory of the Alexandrian school. Euclid, the celebrated author of the *Elements*, lived in the reign of the first Ptolemy. He composed a book on the sphere, which probably served as a model for future works of the same kind, and was the first who treated in a geometrical manner of the phenomena of the different inclinations of the sphere. Conon of Samos, the friend of Archimedes, collected the records of eclipses, which had been observed by the ancient Egyptians; and Callimachus ascribes to him the constellation of Berenice's hair. Archimedes, whose profound genius and deep knowledge of geometry and mechanics entitle him to the appellation of the *Newton* of the ancients, also claims a high rank among the cultivators of astronomy. His celebrated planetarium, which represented the motions of the sun, moon, planets, and starry sphere, has been a frequent theme of the admiration and praises of the poets:

Euclid. Conon. Archimedes.

> Jura poli, rerumque fidem, legesque deorum,
> Ecce Syracusius transtulit arte senex.

Apollonius of Perga solved the important problem of the stations and retrogradations of the planets by means of epicyles and deferents; and he is entitled to the glory of having formed the alliance between the two sciences of geometry and astronomy, which has been productive of the greatest advantages to both.

Apollonius.

Astronomy, which had as yet only consisted of a knowledge of isolated facts, acquired a systematic form, and almost a new existence, from the genius and assiduity of Hipparchus, one of the most astonishing men of antiquity, and perhaps the greatest of all in the sciences which are not purely speculative. This illustrious founder of astronomical science was born at Nice in Bythinia, and ob-

Hipparchus, B. C. 140

served at Rhodes. Flamsteed and Cassini, probably misled by some ambiguous expressions of Ptolemy, have related that his observations were made at Alexandria; and this opinion seems generally to have been adopted by historians. The question has been examined carefully, and at considerable length, by Delambre (*Astronomie Ancienne*), who comes to the conclusion that there is no reason whatever to infer that Hipparchus ever saw Alexandria. Ptolemy, in reporting the observations of Hipparchus, supposed Rhodes and Alexandria to be situated on the same meridian, and consequently does not find it necessary to mention the place at which the observations were made.

Hipparchus commenced his brilliant career by verifying the determination of the obliquity of the ecliptic made by Eratosthenes. He next directed his attention to the length of the tropical year. By comparing an observation of his own, of the summer solstice, with a similar one made by Aristarchus 140 years before, he found that the anciently received value of $365\frac{1}{4}$ days was too great by seven minutes. This leaves the tropical year a value still too great; but it is probable that the error arose from the inaccuracy of the observation of Aristarchus: for the observations of Hipparchus, compared with those of the moderns, make the length of the tropical year amount to 365 days, 5 hours, and 49 minutes, which is only 12 seconds greater than the truth. By a careful observation of the solstices and equinoxes, he discovered that the year is not divided by these points into four equal parts, the sun occupying $94\frac{1}{2}$ days in passing from the vernal equinox to the summer solstice, and only $92\frac{1}{2}$ from the same solstice to the equinox of autumn. The sun, consequently, remained 187 days in that part of the ecliptic which lies between the equator and the north pole, and therefore only about 178 in the other part. This observation led Hipparchus to the great discovery of the eccentricity of the solar orbit. He accounted for the apparent inequality of the sun's motion, by supposing that the earth is not placed exactly at the centre of the circular orbit of the sun, and that consequently his distance from the earth is subject to variation. When the sun is at his greatest distance, he appears to move more slowly; and when he approaches nearer, his motion becomes more rapid. The distance of the earth from the centre of the orbit is called the *eccentricity:* it produces an equation between the real and apparent motions, which is called the *equation of the centre.* He determined the magnitude of this equation in terms of the radius of the ecliptic, and fixed the position of the line of the apsides, or that which joins the two opposite points of the orbit which are at the greatest and least distance from the earth. With these data he formed the first tables of the sun which are mentioned in the history of astronomy. The discovery of the eccentricity also led Hipparchus to that of the inequality of the lengths of the solar days at different seasons of the year. In the interval which elapses between the sun's passage over the meridian and his return to it the following day, the sun advances by his own proper motion towards the east nearly a degree. But the rate of this motion is unequal, varying between 57 and 61 minutes of a degree; and the accumulation of the inequalities forms what is called the equation of time, that is, the difference between the true time, as shown by the sun, and the mean time, shown by a well-regulated clock, the motions of which are equal and uniform.

The attention of Hipparchus was next directed to the motions of the moon; and on this subject his researches were attended with equal success. From the comparison of a great number of the most circumstantial and accurate observations of eclipses recorded by the Chaldeans, he was enabled to determine the period of the moon's revolution relatively to the stars, to the sun, to her nodes, and to her apogee. These determinations are among the most precious relics of ancient astronomy, inasmuch as they corroborate the results of theory in one of its finest deductions—the acceleration of the mean lunar motion—and thus furnish one of the most delicate tests of the truth of Newton's law of gravitation. It was, indeed, by a comparison of the observations of Hipparchus with those of the Arabian and modern astronomers, that Dr Halley was led to the discovery of that curious and important phenomenon. Hipparchus also determined the eccentricity of the lunar orbit, and its inclination to the plane of the ecliptic; and the values which he assigned to these elements, making allowance for the evection and the inequalities of the moon's motion in latitude, are to a few minutes the same as those which are now observed. He had also an idea of the second inequality of the moon's motion, namely, the evection, and made all the necessary preparations for a discovery which was reserved for Ptolemy. He likewise approximated to the parallax of the moon, which he attempted to deduce from that of the sun, by determining the length of the frustum cut off from the cone of the terrestrial shadow by the moon when she traverses it in her eclipses. From the parallax he concluded that the greatest and least distances of the moon are respectively equal to 78 and 67 semi-diameters of the earth, and that the distance of the sun is equal to 1300 of the same semi-diameters. The first of these determinations exceeds the truth; the second falls greatly short of it, the distance of the sun being nearly equal to 24,000 terrestrial semi-diameters. It may, however, be remarked that Ptolemy, who undertook to correct Hipparchus with regard to the parallax, deviated still farther from the truth.

The apparition of a new star in the time of Hipparchus induced him to undertake the formation of a catalogue of all the stars visible above his horizon, to fix their relative positions, and mark their configurations, in order that posterity might have the means of observing any changes which might in future take place in the state of the heavens. This arduous undertaking was rewarded by the important discovery of the precession of the equinoxes, one of the fundamental elements of astronomy. By comparing his own observations with those of Aristillus and Timocharis, he found that the first point of Aries, which, in the time of these astronomers, or 150 years before, corresponded with the vernal equinox, had advanced two degrees, according to the order of the signs, or at the rate of 48 seconds a year. This determination is not very far from the truth; for, according to modern observations, the rate of the precession is about 50·1 seconds annually. His catalogue contained 1080 stars: it is generally, but erroneously, stated to have contained only 1022, after that of Ptolemy, in which the nebulous and some obscure stars are omitted. He also commenced a series of observations to furnish his successors with the means of forming a theory of the planets. Hipparchus likewise invented the planisphere, or method of representing the starry firmament on a plane surface, which afforded the means of solving the problems of spherical trigonometry in a manner often more exact and more commodious than the globe itself. He was the first who demonstrated the methods of calculating triangles, whether rectilineal or spherical; and he constructed a table of chords, from which he drew nearly the same advantages as we derive at present from the tables of sines. Geography is also indebted to him for the happy idea of fixing the position of places on

History. the earth by means of their latitudes and longitudes; and he was the first who determined the longitude by the eclipses of the moon.

These various labours and brilliant discoveries give a high idea of the industry and genius of Hipparchus. His writings have unfortunately all perished, excepting a commentary on the poem of Aratus; but the principal elements of his theories, together with a few observations, have been preserved in the Almagest of Ptolemy.

After the death of Hipparchus, nearly three centuries elapsed before any successor arose worthy of the name. During this long period astronomy gained no essential advancement. Some rude observations, scarcely superior to those of the Chaldeans, and a few meagre treatises, are the only monuments which exist to testify that science had not fallen into utter oblivion in an age so fertile of poets and orators. Geminus and Cleomedes wrote treatises, which have been preserved to our times; Agrippa and Menelaus are said to have observed; the Roman calendar was reformed by Julius Cæsar and the Egyptian astronomer Sosigenes; and Posidonius measured a degree, and remarked that the laws of the tides depend on the motions of the sun and moon.

Ptolemy, A. D. 130. Ptolemy was born at Ptolemais in Egypt, and flourished at Alexandria about the 130th year of our era, under the reigns of Adrian and Antoninus. This illustrious ornament of the Alexandrian school is entitled by his own discoveries to the high rank among astronomers which has universally been assigned to him; but the most signal service which he conferred on science was the collection and arrangement of the ancient observations. Out of these materials he formed the Μεγαλη Συνταξις, or *Great Composition*, a collection which exhibits a complete view of the state of astronomy in the time of Ptolemy, and which contains the germ of most of the methods in use at the present day.

The hypothesis which Ptolemy adopted for the purpose of explaining the apparent motions, was that which had been followed by Hipparchus. We have already seen that the genius of Pythagoras, soaring above the illusions of sense, had conceived the sun to be situated at the centre of the universe, and the earth to circulate, like the other planets, about the sun; and that the same opinion was entertained and supported by Aristarchus and a few other astronomers. It would seem, however, that this philosophical idea never gained much ground in antiquity, even among the learned. The vulgar prejudice respecting the immobility of the earth continued to prevail; and it had become an inveterate axiom, that all the celestial motions must be circular and uniform. Ptolemy himself, who felt in its full force the difficulty of reconciling the appearances with the notion of a uniform circular motion, adopted the common opinion without scruple as a primordial law of the universe; for, says he, this perfection belongs to the essence of celestial things, which neither admit of disorder nor irregularity. To save this chimera—the uniform circular motion—Apollonius imagined the ingenious apparatus of epicycles and deferents; and Hipparchus advanced a step farther, by placing the centre of the sun's circle at a small distance from the earth. Ptolemy adopted both hypotheses, and supposed the planet to describe an epicycle by a uniform revolution in a circle, the centre of which was carried forward uniformly in an eccentric round the earth. By means of these suppositions, and by assigning proper relations between the radii of the epicycle and deferent circle, and also between the velocity of the planet and the centre of its epicycle, he was enabled to represent with tolerable accuracy the apparent motions of the planets, and particularly the phenomena of the stations and retrogradations, which formed the principal object of the researches of the ancient astronomers. The notions of Apollonius and Hipparchus were thus reduced to a systematic form, and the proportions of the eccentrics and epicycles of all the planets assigned, by Ptolemy; on which account the system has been generally ascribed to him, and obtained the name of the *Ptolemaic System* of the universe. As a first attempt to bring the celestial motions within the grasp of geometry, it does infinite honour to the genius of its inventors. It is, however, totally irreconcilable with the precision of modern observations; for it is impossible to represent on this hypothesis the variations of the distances of the planets at the same time with their apparent motions. But this difficulty could scarcely be felt by Ptolemy, inasmuch as it was impossible, before the invention of the telescope and micrometer, to form any accurate estimate of the variations of the apparent diameter of a planet, and consequently of its distance. It must be admitted, however, that the Ptolemaic hypothesis might be sufficient for the wants of practical astronomy, that is, for calculating the places of the planets and forming tables of their motions, were it not for its extreme complication. The discovery of every new irregularity in the planetary motions exacts the addition of a new epicycle; and such was the confusion resulting from this circumstance, that Alphonso X., despairing of being able to comprehend the complicated machinery, was tempted to exclaim, that if the Deity had called him to his counsels at the creation of the world, he could have given good advice. Yet, notwithstanding all its defects, the system of Ptolemy gained a complete ascendency over the minds of mankind, and, so difficult is it to leave the beaten path, continued to be implicitly followed by every astronomer during fourteen centuries, having been only finally exploded by Kepler's discovery of the elliptic orbit of Mars.

The most important discovery which astronomy owes to Ptolemy is that of the *Evection* of the moon. Hipparchus had discovered the first lunar inequality, or the equation of the centre, which serves to correct the mean motion at the syzygies, and had also remarked the necessity of another correction for the quadratures. He even undertook a set of observations, with a view to ascertain its amount and its law; but death put a stop to his labours before he had brought them to a successful issue. Ptolemy completed the investigation, and discovered that the eccentricity of the lunar orbit is itself subject to an annual variation, depending on the motion of the line of the apsides. The variation of the position of the apsides produces an inequality of the moon's motion in her quarters, which has been technically denominated the evection. The equation given by Ptolemy, though of course empirical, is remarkably exact.

Ptolemy employed a very simple process for determining the moon's parallax, which was probably suggested to him by the situation of Alexandria, where he observed. He determined the latitude of a place a little to the south of that city, over the zenith of which the moon was observed to pass when her northern declination was the greatest possible. But when the moon is in the zenith, or in the same straight line with the observer and the centre of the earth, she has no parallax; consequently the obliquity of the ecliptic and the latitude of the station being known, the moon's greatest northern latitude was also determined. The next step was to observe the moon's meridian altitude fifteen days after the first observation, when her southern latitude was necessarily the greatest possible. This observation gave the *apparent* altitude of the moon, but her greatest northern and southern decli-

nations being supposed equal, her *true* altitude, as seen from the centre of the earth, was easily computed from the previous observation, and the difference between the true and apparent altitudes gave the amount of the parallax.

The observations of Hipparchus relative to the motion of the stars in longitude, or the regression of the equinoctial points, were confirmed by Ptolemy, although he mistook its amount, and diminished a quantity which Hipparchus had already estimated too low. According to Hipparchus, the regression is at the rate of two degrees in 150 years. Ptolemy reduced it to one degree in 90 years. This disagreement would seem to indicate an error of more than a degree in the observations, which can with difficulty be admitted, considering the accordance which subsists among the different observations cited by Ptolemy in support of his own determination. For this and some other reasons Ptolemy has been accused of altering the observations of Hipparchus, and accommodating them to his own theory; but there does not appear to be any just ground for the imputation. The error with regard to the regression probably arose from the circumstance, that Hipparchus had assigned too great a value to the length of the year, whence the motion of the sun with regard to the equinoxes would be made too slow, and the longitudes employed by Ptolemy consequently diminished.

Ptolemy has been called the *Prince* of astronomers,—a title which may perhaps be justified by the universal and long-continued prevalence of his system, but to which he has no claim from the number or value of his own observations. After a laborious and minute examination of the Almagest, Delambre doubts whether any thing, saving the author's declarations, is contained in that great work, from which it can be decisively inferred that Ptolemy ever observed at all. He indeed frequently makes mention of observations made by himself; but his solar tables, rate of the precession, eclipses, determination of the moon's motion and parallax, and, above all, his catalogue of stars, render it impossible to doubt that the greater part of the results which he has given as observations are merely computed from the tables of Hipparchus. It is therefore difficult to allow to Ptolemy that good faith and "astronomical probity which forms one of the most indispensable qualities of an observer." He never in any instance cites a single observation more than is just necessary for the object he has immediately in view, and consequently, by precluding all comparison of one observation with another, has deprived us of the means even of guessing at the probable amount of the errors of his solar, lunar, and planetary tables. If an astronomer, as Delambre justly remarks, were to adopt the same course at the present day, he would be certain of forfeiting all claim to confidence; but Ptolemy stood alone; he had neither judges nor rivals; he claimed admiration, and received it; and now no one condescends to calculate the few observations he has left us. (Delambre, *Astronomie Ancienne*, tom. i. Discours Préliminaire.) His catalogue contains only 1029 stars, and is therefore less extensive than that of Hipparchus, but it is exceedingly valuable on account of its details.

The name *Almagest* (Μεγιστη, with the Arabic prefix) was bestowed on the *Syntax* by the Arabians, into whose language it was translated in the ninth century. The first Latin translation was from the Arabic, and published at Venice in 1515. It abounds in Arabic words and idioms, and is very inaccurate and barbarous. The second Latin translation was made from the original Greek by George of Trebizond, and is greatly superior to the first. It was published at Basle in 1541, and in 1551. The Greek text was published at the same time in 1538. Ptolemy was the author of numerous other works connected with astronomy, of which his *Geography*, in eight books, is the best known. It contains a list of all the places of which the latitudes and longitudes had at that time been determined. His treatise on *Optics* was supposed to be lost, till an imperfect Latin translation, from an Arabic version, was lately discovered in the king's library at Paris. The last book of this work contains a theory of astronomical refraction, more complete than any which existed before that of Cassini. It would seem that Ptolemy had not discovered the refraction at the time he composed the Almagest, no mention being made of the subject in that work. The explanation which he gives of the phenomenon is natural and satisfactory, indeed entirely conformable with that which is now universally adopted. The idea and explanation remained buried in the *Optics* till reproduced by Alhazen; but neither Ptolemy nor Alhazen attempted to estimate the amount of the refraction. His *Planisphere* and *Analemma*, in which he treats of the stereographic and orthographic projections of the sphere, show a perfect acquaintance with spherical trigonometry. In the last-mentioned work he makes use of the sines, and his constructions comprehend three of the four general theorems in modern use. Divers treatises also on music, dialling, chronology, and mechanics, attest the universality of Ptolemy's genius, and his unremitting application to the pursuits of science. Like Archimedes, he had a desire to transmit to posterity the history of his labours by a public monument. In the temple of Serapis, at Canopus, he is said to have consecrated a marble pillar, with an inscription containing the principal elements of his astronomy, such as the length of the year, the eccentricity of the solar and lunar orbits, the dimensions and forms of the epicycles of the planets, &c.

Decline of astronomy.

On the death of Ptolemy astronomy ceased to be cultivated among the Greeks. The Alexandrian school subsisted indeed for some centuries after; but genuine science had fled, and its place been usurped by the vain wranglings of theologians and grammarians. During the long period of six or seven centuries, the labours of those who assumed the name of astronomers were confined to needless or trifling commentaries on the works of Hipparchus and Ptolemy, and were productive of no observations, or even remarks, having a tendency to enlarge the boundaries of the science. The genius of the Roman dominion was unfavourable to the development or exercise of the higher faculties of the human intellect; and the natural sciences, with the liberal arts, faded away under the withering influence of military despotism.

From the brief account which has now been given, it will be easily inferred that the Greeks cultivated astronomy rather as a speculative than a practical science. None of their numerous sects ever evinced any taste for observation or experiment; and hence, while geometry made great and rapid advances in their hands, physics and experimental philosophy were entirely neglected. The prevailing passion for speculation pervaded even their astronomy. They explained the doctrine of the sphere, and the apparent motions of the planets; and framed ingenious theories to account for such phenomena as came immediately under the cognizance of their senses; but if we except the observations of Hipparchus and Ptolemy, and perhaps two solstitial distances of the sun from the zenith, observed by Eratosthenes, we remark among them no observations made with instruments capable of measuring angular distances. Before Hipparchus, no mention is made of the astrolabe; and the recorded determinations do not

History. give us a very favourable idea of the accuracy of that instrument. On casting our eyes over the catalogue of Ptolemy, we scarcely ever meet with a fraction of a degree smaller than one-twelfth, that is to say, less than five minutes; whence we may infer that the astrolabe only measured twelfth parts of a degree. Occasionally, indeed, the fractions one-fourth and three-fourths occur; but these were most probably inserted by estimation. The Greeks of Alexandria committed an error of no less than 15′ with regard to the altitude of the pole, one of the most essential elements to an observer; and it does not appear that they were ever able to determine the time to within a quarter of an hour. Yet notwithstanding these circumstances, which indicate that the art of observation was still in its infancy, the science of astronomy is vastly indebted to the labours and speculations of the Greeks. The complicated but ingenious hypotheses of Ptolemy prepared the way for the elliptic orbits and laws of Kepler, which, in their turn, conducted Newton to the great discovery of the law of gravitation.

Astronomy of the Arabians.

While the nations of western Europe were involved in the thickest shades of ignorance and barbarism, the torch of science was rekindled, and blazed forth with extraordinary splendour, among the Saracens. The burst of fanaticism which enabled the followers of Mahomet to carry their religion and their arms over the fairest portion of the ancient world subsided, in a great measure, after a century and a half of uninterrupted conquest, and was succeeded by a period of repose, during which they cultivated the arts of peace and civilisation with the same ardour which had characterized their achievements in arms. Under the enlightened and munificent protection of the caliphs, Bagdat became what Alexandria had been under the Ptolemies, the centre of politeness and knowledge.

The accounts which we possess of the Saracen literature are imperfect and scanty; but the first of the caliphs who appears to have encouraged the study of astronomy was Abougiafar, surnamed Almansor, or the Victorious, who reigned in the eighth century. His grandson Almamon, the seventh of the Abassides, and second son of the famous Haroun Al Raschid, who reigned at Bagdat from 813 to 833, is celebrated for the protection which he gave to learning, and the zeal with which he laboured to propagate the sciences of the Greeks among his subjects. In granting peace to the emperor Michael III., he stipulated for liberty to collect in Greece all the writings of the philosophers. These he transported into his own country, and caused to be translated into Arabic. Finding it mentioned in the geography of Ptolemy that a degree of the earth was equivalent to 500 stadia, he resolved to have this fact verified by a new measurement; and in obedience to the commands of the caliph, a company of mathematicians assembled in the spacious plain of Sinaar, where, having observed the altitude of the pole, they separated themselves into two parties, and proceeded in opposite directions along the meridian, measuring the distance they passed over till the altitude of the pole varied one degree. Being unacquainted with the nature of the instruments made use of in these geodetic operations, we cannot estimate the probable accuracy of the result; but as it agreed perfectly with the statement of Ptolemy, we have a right to infer that the measurement was executed in a very inadequate manner, and that the mathematicians of the caliph adopted the ancient determination from want of confidence in their own.

The *Syntax* of Ptolemy was translated into Arabic under the reign of Almamon, by Isaac Ben Honain. The translation was afterwards revised by Thabet or Thebith Ben Korah, and it was about this time that it received the appellation of Almagest. Astronomical observations, which, as we have had occasion to remark, had been greatly neglected by the successors of Hipparchus, formed a principal object of the attention of the Arabians. By the orders of Almamon, the obliquity of the ecliptic was observed, and found to be 23° 33′. According to the modern tables, the obliquity at that time was 23° 36′ 34″, so that the error was less than that of Hipparchus and Ptolemy, in their determination of the same element. This observation supposes instruments of some accuracy. Among the astronomers whom Almamon drew to his court, we find the names of Habash of Bagdat, who composed three books of astronomical tables; Ahmed, or Mohammed Ben Cothair, better known by the name of Alfragan, or Alfranius, who, from his great expertness in computing, was styled the *calculator*. He composed an elementary treatise on astronomy, which was only an abridged extract of the works of Ptolemy; and likewise wrote on sun-dials, and gave a description of the astrolabe. The Jew Meshala, whose treatise on the elements was published at Nuremberg in 1549, also lived in the time of Almansor or Almamon.

Albategnius.

The most celebrated of the Arabian astronomers was Albategnius, or Muhammed Ben Geber Albatani, so called from Batan, a city of Mesopotamia, where he was born. He was a prince of Syria, and resided at Aracte or Racha, in Mesopotamia; but many of his observations were made at Antioch. Having studied the *Syntax* of Ptolemy, and made himself acquainted with the methods practised by the Greek astronomers, he began to observe, and soon found that the places assigned to many of the stars in Ptolemy's tables were considerably different from their actual situations, in consequence of the error which that great astronomer had committed with regard to the precession of the equinoxes. Albategnius measured the rate of the precession with greater accuracy than had been done by Ptolemy; and he had still better success in his attempt to determine the eccentricity of the solar orbit, his value of which differs extremely little from that which results from modern observations. In assigning the length of the year, however, he fell into an error of more than two minutes; but this proceeded, as has been shown by Dr Halley, from too great confidence in the observations of Ptolemy. Albategnius also remarked that the place of the sun's apogee is not immovable, as former astronomers had supposed, but that it advances at a slow rate, according to the order of the signs,—a discovery which has been confirmed by the theory of gravitation. A new set of astronomical tables, more accurate than those of Ptolemy, likewise resulted from the indefatigable labours of Albategnius; and his observations, important in themselves, are doubly interesting on account that they form a link of connection between those of the astronomers of Alexandria and of modern Europe. The works of Albategnius were published in 1537, under the title of *De Scientia Stellarum.*

Thebith Ben Korah.

Thebith Ben Korah, another Arabian, acquired celebrity by proposing an explanation of the motions of the stars, which, under the name of the "System of Trepidation," was eagerly received by the astronomers of the middle ages, and disfigured the tables of Alphonso, and even those of Copernicus. He ascribed to the *eighth* sphere, or that of the fixed stars, two motions; one the diurnal motion, the other that of trepidation, performed in small circles round the first points of Aries and Libra, and of

History. which the radii were 4° 18′ 33″. He therefore supposed two ecliptics, one fixed in the ninth sphere, the other movable in the eighth. According to this construction, the motion of the stars is sometimes direct and sometimes retrograde.

The Arabians have been said to be not only the cultivators but the apostles of the sciences, on account of the activity with which they propagated them among all the nations subjected to their dominion. The Fatimite caliphs, who reigned in Egypt during two centuries, rivalled their predecessors the Ptolemies in the encouragement which they gave to astronomy. Under the caliph Hakem, Ebn Jounis. who reigned from 996 to 1021 of our era, Ebn Jounis acquired a splendid reputation. He constructed a set of tables, and composed a sort of celestial history, in which he has recorded numerous observations of his own and of other astronomers belonging to the same country. This work, imperfectly known through some extracts, long excited the curiosity of astronomers, as it was supposed to contain observations tending to establish the acceleration of the mean motion of the moon. A manuscript copy of it, belonging to the university of Leyden, was, in 1804, transmitted to the French Institute, and translated by Professor Caussin. It contains 28 observations of eclipses from the year 829 to 1004; seven observations of the equinoxes; one of the summer solstice; one of the obliquity of the ecliptic made at Damascus, by which the value of that element is found to be 23° 35′; and likewise a portion of tables of the sun and moon, with some other matter illustrative of the state of astronomy among the Arabians. The observations which regard the acceleration of the mean lunar motion are two eclipses of the sun and one of the moon, observed by Ebn Jounis, near Cairo, in the years 977, 978, and 979, and they agree with theory in confirming the existence of that phenomenon.

The Saracen conquests in Spain were attended with the same happy results as in Egypt, and science flourished in that country while the rest of Europe was involved Arzachel. in the darkest shades of ignorance. Arzachel is supposed to be the author of the *Toledo Tables*, constructed about the year 1180, but which, on account of the established reputation of those of Albategnius, were never in great estimation. He made some changes in the dimensions which had been assigned by Hipparchus and Ptolemy to the solar orbit, and deserves the praise of having been an Alhazen. exact and attentive observer. Alhazen, who flourished in the same country about the same period, contributed to the progress of astronomy by a treatise on *Optics*, in which he clearly indicated the necessity of making an allowance for the celestial refraction in astronomical observations. His treatise contained a theory of reflection and refraction, an explanation of the cause of the twilight, Averroes. and of the magnitude of the horizontal moon. Averroes, a physician of Cordova, made an abridgement of the Almagest in the twelfth century, and Almansor found the obliquity of the ecliptic to be 23° 33′ 30″, which proves that practical astronomy had now attained to a tolerable degree of exactness.

If we inquire what effect the labours of the Arabians and their disciples had on the progress of astronomy, we shall find that their services were confined entirely to the practical part. In point of theory they did absolutely nothing. They admitted all the hypotheses of Ptolemy without the slightest alteration, even with timid and superstitious respect, and did not advance a single step towards the discovery of the solar system. But with regard to instruments and methods of calculation, their improvements were numerous and important. They constructed instruments on a larger scale, and divided them with greater care; and, even from the time of Almamon, we remark among them new and more exact determinations of the obliquity of the ecliptic, of the positions of some stars, of the precession, of the length of the year, and of the eccentricity of the sun's orbit. To these fundamental points they added numerous observations of eclipses and conjunctions; they industriously sought out and corrected the errors of Ptolemy's tables; they perceived the necessity of marking the instant of each phenomenon with greater care; and their determinations of the commencement and end of eclipses are in general accompanied with the altitude of a star, which afforded them the means of calculating the hour, angle, and the true time. In cases where less precision was wanted, they made use of their clepsydræ and solar dials, to the construction of which they paid particular attention. Trigonometry derived signal advantages from their constant care to facilitate the calculations of spherical astronomy. Albategnius substituted the sines for the chords,—a most important improvement, the idea of which was probably suggested to him by the Analemma of Ptolemy. By this happy substitution the solution of all rectangular spherical triangles was reduced to four general formulæ, of which the Greeks had the equivalent in a much less commodious form. The same astronomer also appears to have invented a very remarkable rule for the oblique-angled triangles, perfectly identical with one of the four general formulæ now in use. Ebn Jounis, and his contemporary Aboul Wefa, were acquainted with the tangents and secants, and employed them very dexterously in reducing complicated binomial expressions to a single and simpler term. They also employed subsidiary arcs and other artifices in the calculus of the sines, in order to facilitate the labour of computation. These substitutions are now common; but they remained long unknown in Europe; and 700 years after they were employed by the Arabians, we first meet with some examples of their use in the writings of Thomas Simpson.

The zeal of the Arabians for astronomical observations Holegu-Ilecou-Khan. was communicated by them to the Persians and Tartars. died 1269. About the year 1072, Omar Cheyam determined the length of the tropical year, and introduced the calendar which has ever since been used in Persia. Holegu-Ilecou-Khan, who conquered that country about the year 1264, caused an observatory to be built at Maragha, near Tauris, where he assembled the most celebrated astronomers who could be found within his dominions, and employed them in forming new astronomical tables. This work was directed by the famous Nassireddin, and brought to a conclusion in the year 1269. With the exception of some trifling corrections of the mean motions, the whole of these tables are copied from Ptolemy.

Ulugh Beigh, a Tartar prince, and grandson of the great Ulugh Beigh, Tamerlane, not only encouraged the study of astronomy, died 1449. but was himself a diligent and successful observer. At Samarcand, the capital of his dominions, he established an academy of astronomers, and caused the most magnificent instruments to be constructed for their use. By means of a gnomon 180 feet in height, he determined the obliquity of the ecliptic to be 23° 30′ 20″, the precession of the equinoxes at 1° in 70 years, and obtained elements for the construction of tables which have been found to be scarcely inferior in accuracy to those of Tycho Brahé. The ancient astronomy had produced only one catalogue of the fixed stars, that of Hipparchus. Ulugh Beigh has the honour of having formed a second, after an interval of sixteen centuries. This learned and munificent prince, whose virtue and talents deserved the esteem of mankind, was assassinated by his own son in the 58th year of his age.

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Revival of Astronomy in Europe.

After the death of Ulugh Beigh, astronomy received no farther accessions in the east. But the seeds of knowledge had now begun to take root in a more propitious soil, and Europe, destined to carry the development of the human energies to its fullest extent, began to awake from the lethargy in which it had continued during so many ages. The first dawnings of returning day appeared in Spain. In spite of the horror inspired by the Moslem religion, the Christians began to perceive and acknowledge the superiority and utility of the science of the Moors; and the schools of Cordova became the resort of all those whom curiosity, or love of knowledge, induced to seek abroad for that information which could not be obtained in their own countries. Geber, afterwards Pope Silvester II., acquired the knowledge of arithmetic from that source; and John of Halifax, better known by the name of Sacrobosco, after having studied some time in Spain, made an abridgement of the Almagest, which was long famous under the title of a *Treatise of the Sphere.*

Frederick II.

The emperor Frederick II. is no less celebrated for his protection of the sciences, than for the continual struggles in which he was involved with the popes. He founded the university of Naples, and caused Latin translations to be made of the works of Aristotle and the Almagest of Ptolemy. About the same time astronomy was zealously encouraged and cultivated by Alphonso X., king of Castile. This monarch, whose liberal mind seems to have been far superior to the age in which he lived, formed a college or lyceum at Toledo, the capital of his dominions, whither he assembled the most eminent astronomers that could be found, whether Christians, Moors, or Jews, and engaged them in the task of correcting the errors of the ancient tables. From their united labours were produced the *Alphonsine Tables*, which obtained great celebrity, and were, in some respects, superior in accuracy to any which had preceded them. They are supposed to have been chiefly the work of the Rabbi Isaac Aben Sid, surnamed Hazan, inspector of the synagogue of Toledo. They are said to have cost the king 40,000 ducats,—a sum certainly far exceeding their real value, which is confined to the correction of some epochs, and a more accurate determination of the sun's motions and the length of the year. The same century gave birth to several other individuals distinguished by their attachment to the sciences. Campanus of Nivari translated Euclid, and left a treatise on the sphere. Vitello, a native of Poland, composed a treatise on optics, in ten books; and Albert, bishop of Ratisbon, whom his contemporaries styled the *great*, was the author of some works on arithmetic, geometry, astronomy, and mechanics. But the greatest luminary of that age was Roger Bacon, a Franciscan friar, whose numerous works contain many indications of a powerful and inventive genius. He made many important discoveries in optics; but his knowledge of natural philosophy and chemistry, uncommon in those days, had nearly proved fatal to him; for he was suspected of necromancy, and thrown into a dungeon, from which he did not escape till he had satisfied his superiors and the pope that he had never held unlawful intercourse with the devil. He composed a work on the utility of astrology, the places of the stars, and the aspects of the moon; and he had the merit of perceiving the necessity of reforming the calendar.

Alphonso X., died 1284.

Roger Bacon, born 1214, died 1294.

Purbach, born 1423, died 1461.

The fourteenth century produced no astronomer from whose labours the science gained any accessions. George Purbach, or Beurbach, so named from a small town in Austria, where he was born in 1423, obtained great celebrity as a professor. He studied at Vienna, and after giving proofs of distinguished talents, he travelled into Italy, where he was favourably received by the cardinal of Cusa, who himself cultivated astronomy. On his return to Vienna he undertook a translation of the Almagest; and although ignorant both of Greek and Arabic, his perfect acquaintance with the subject enabled him to correct many errors which had been introduced through the carelessness or ignorance of former translators. He published a table of sines for every ten minutes to a radius of 6,000,000 parts, which was afterwards extended by his scholar Regiomontanus to every minute of the quadrant. The most celebrated of his works is his *Theoricæ Novæ Planetarum*, which was published in 1460. He constructed a celestial globe, on which was represented the motion of the stars in longitude from the time of Ptolemy to the year 1450. He also measured the obliquity of the ecliptic, and is considered as the inventor of decimal arithmetic. He died in 1461, having only reached his 38th year, with the reputation of being, at that time, the first astronomer in Europe.

Regiomontanus, born 1436, died 1475.

Purbach had the good fortune to form a disciple who executed many of the plans which had been interrupted by his premature death. This was the celebrated John Muller of Königsberg, better known by the name of Regiomontanus. Attracted in his youth to Vienna by the great reputation of Purbach, he continued to study there during ten years, and on the death of his master repaired to Rome for the purpose of acquiring the Greek language, and of making himself, through it, acquainted with the Almagest. At Rome he continued his observations, and translated into Latin the works of Ptolemy, the *Conics* of Apollonius, and some other treatises of ancient science. In 1471 he retired to Nuremberg, where, with the aid of Bernard Walther, a wealthy burgess, he founded an observatory, and furnished it with excellent instruments, principally of his own invention, by means of which he was enabled to detect many errors in the ancient tables. On the invitation of Pope Sixtus IV., who wished to reform the calendar, he again repaired to Rome; but after a few months' abode there he died suddenly, according to some accounts, of the plague, according to others, through the effects of poison administered to him by the sons of George of Trebizond, who adopted this execrable method of revenging the exposure which he had made of their father's errors in the translation of the Almagest. Regiomontanus was a learned and skilful man, but the great expectations which his early labours gave of future services to astronomy were disappointed by his untimely death. He paid great attention to trigonometrical calculation; and, although he did not reach the point which had been attained by the Arabians, he had the merit of introducing some useful theorems which till then were entirely unknown in Europe. His genius, however, did not enable him to rise above the prejudices of his age, for he was an astrologer as well as an astronomer, and is said to have most lamented the errors of the Alphonsine Tables on account of the uncertainty which they occasioned in the calculation of genitures or horoscopes.

Walther, born 1430 died 1504

After the death of Regiomontanus, Walther continued to observe at Nuremberg during thirty years. His observations were collected by order of the senate of Nuremberg, and published by Schöner in 1544, a second time by Snellius, and, lastly, along with those of Tycho Brahé. In 1484 Walther began to make use of clocks, then a recent invention, to measure time in celestial observations. He was also the first who employed the planet Venus as a term of comparison for determining the longitudes of the stars.

Nuremberg had the honour of producing another astro-

Werner born 1468.

nomer of some celebrity. John Werner was the first who explained the method which was afterwards brought into general use by Maskelyne, of finding the longitude at sea, by observing the distance between a fixed star and the moon. He published some mathematical and geographical treatises, and made a number of observations to determine the obliquity of the ecliptic and the precession of the equinoxes.

Overthrow of the Ptolemaic system.

We are now come down to a period in the history of astronomy when the science was destined to undergo a total renovation, and the system which had been so laboriously established by Ptolemy, and blindly followed as an article of religious belief by Arabs, Persians, Tartars, and Europeans, during so many centuries, was about to be exploded for ever. In proportion as the observations became more numerous and accurate, the difficulty of representing them by the Ptolemaic system became greater; and astronomers were obliged to have recourse to the most violent and improbable suppositions in order to explain the phenomena, and, in the language of Ptolemy, *save* the appearances. We have mentioned that Pythagoras and his disciples entertained an idea very different from that which commonly prevailed, and supposed the sun to be the immovable centre of the celestial motions. It appears, however, from Aristotle, that this opinion was not founded on any analysis of the phenomena, but on certain metaphysical notions respecting the comparative dignity of the several elements. For example, fire, being a nobler substance than earth, ought to occupy the centre or place of honour. But such arguments could have little weight except in the schools, and accordingly were rejected by Ptolemy as too absurd to require a serious refutation. In order to give any probability to the Pythagorean doctrine, it was necessary to explain the succession of the seasons and the precession of the equinoxes on the hypothesis of the annual revolution of the earth about the sun; to show how the unequal motions of the planets in concentric orbits would give rise to the phenomena of the stations and retrogradations; to account, in short, for all the appearances, and point out their coherence and mutual connection. All this was effected by Copernicus, who had thereby the glory of first making known the true system of the universe, and of leading the way in that career of astronomical discovery in which the genius of the human race has gained its noblest trophies.

Copernicus, born 1472, died 1543.

Nicholas Copernicus was born at Thorn, a city of Prussia, on the confines of Poland, according to Junctinus on the 19th of January 1472, and according to others on the 19th February 1473. From his earliest years he displayed a great fondness and aptitude for mathematical studies, and pursued them with corresponding success at the university of Cracow. Stimulated by the desire of acquiring a reputation equal to that of Regiomontanus, he set out for Italy at the age of 23 years, in order to study astronomy at Bologna under the celebrated Dominic Maria. He afterwards removed to Rome, where he employed himself in studying and teaching the mathematics, and where he made several astronomical observations about the year 1500. On his return to his native country he was made a canon of Ermeland by his uncle the bishop of Worms, and took up his residence at Frauenberg, a small Prussian town near the mouth of the Vistula, where he passed 36 years of his life in observing the heavens and meditating on the system of the world. In this retirement he composed his famous work entitled *Astronomia Restaurata, sive de Revolutionibus Orbium Cœlestium*, in which he explained the celestial motions in a manner as simple and connected as the system of Ptolemy was complicated and incoherent. The system which Copernicus adopted in this work is now so familiar to every one, that it is almost unnecessary to describe it. The heaven, composed of stars perfectly at rest, occupies the remotest bounds of space, then the orbit of Saturn, next Jupiter, Mars, the Earth accompanied by its moon, Venus, Mercury, and, lastly, the Sun immovable at the centre. By this arrangement the stations and retrogradations of the planets became simple mathematical corollaries, following from the differences of the radii of their orbits and their unequal motions. The diurnal rotation of the earth explained more simply and rationally the apparent daily revolution of the heavens; and the precession of the equinoxes was referred to a small variation in the inclination of the earth's axis to the plane of the ecliptic. But the simplicity of the system, and its consequent probability, were the only arguments which Copernicus was able to bring forward in proof of its reality. The motion of the earth can indeed never be made an object of sense; but after Richer's discovery of the diminution of gravity towards the equator, it was impossible to doubt longer of the existence of its rotatory motion; and when Roemer had measured the velocity of light, and Bradley observed the phenomena of the aberration, the evidences of its annual revolution were rendered equally convincing. Great, however, as were the merits of Copernicus, it must be acknowledged that he left his system in a very imperfect state. After the example of the ancients, he assumed as an axiom the uniform circular motion of the planets; and as the only motions which are observed are in a state of incessant variation, he was obliged, in order to save the inequalities, to suppose a different centre to each of his orbits. The sun was placed *within* the orbit of each of the planets, but not in the centre of any of them, consequently he had no other office to perform than to distribute light and heat; and, excluded from any influence on the system, he became as it were a stranger to all the motions. Yet notwithstanding these and other imperfections, the establishment of the doctrine of the earth's motion, with an evidence which dissipated the illusions of sense, was a great step towards the true knowledge of the planetary system; and when we consider the ignorance and prejudices of the age, and that Copernicus was moreover a priest, we cannot hesitate to admit his claim to a high rank among philosophers. But whether the actual services which he rendered to astronomy are commensurate with the great fame he has obtained, may admit of doubt. He revived an ancient opinion opposed to the prejudices and religious dogmas of his times, and fortified it with new and strong, though not absolutely convincing, proofs. It seldom happens, however, with regard to those sciences which ultimately appeal to experience, that general reasoning, even of the soundest kind, tends much to their real advancement; and there is little reason for thinking that astronomy would have been less perfect, or that any discoveries since made in it would have been retarded a single day, even if Copernicus had never lived. His great merit, like that of Lord Bacon, consists in the sound views which he took of nature, and in advancing so far before the general attainments of his age.

Fearing the opposition which was likely to arise from religious bigotry to opinions so much at variance with vulgar prejudice, Copernicus long delayed the publication of his great work; and it was only at the urgent request of his friends that he at last allowed it to be printed. He is said to have received the last sheet of it only on the day of his death. He was buried in the cathedral of Frauenberg, and his only epitaph consisted of some spheres cut out in relief on his tombstone.

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The ideas of Copernicus soon spread over Germany, where astronomy was at that time diligently cultivated; but they do not seem to have met with general favour before the commencement of the seventeenth century. The art of observing was, however, gradually receiving improvement; instruments were constructed on better principles, and more accurately divided; and the methods of computation were rendered much less laborious. Nonius, or Nunez, a Portuguese, invented the ingenious method of subdividing the small divisions of instruments which still retains his name; Reinhold extended the table of tangents of Regiomontanus to every minute of the quadrant, reformed the tables of Copernicus, and composed many works of practical utility; but of the immediate successors of Copernicus, no one deserves to be more honourably mentioned than William IV., landgrave of Hesse. This prince built a magnificent observatory on the top of his palace at Cassel, which he furnished with excellent instruments of copper, and is said to have calculated himself the positions of no less than 400 stars. He was aided in the labours of the observatory by some astronomers of great merit whom his liberality drew to his court; among others, by Rothman, and Justus Byrgius, a distinguished artist, to whom Kepler has ascribed some idea of the logarithms.

Nonius, born 1497, died 1577.

William IV., died 1592.

Tycho Brahe, born 1546, died 1601.

Tycho Brahe, one of the best and most indefatigable observers of whom practical astronomy can boast, was born at Knudstorp, in Scania, the 13th of December 1546. His family was one of the most ancient and noble in Denmark; and his father, probably thinking that illustrious birth superseded the necessity of education, refused his consent to have his son instructed in Latin. Through the kindness of a maternal uncle, however, he was rescued from the state of barbarous ignorance to which he had been doomed by his parent; and, after having received the requisite preliminary instruction, he was sent to the university of Leipsic to study jurisprudence and scholastic philosophy. The tastes of the future astronomer were first excited by an eclipse of the sun which happened in 1560. Struck with astonishment at the accuracy of the prediction, he conceived a vehement desire to become acquainted with the principles of so certain a science, and exerted his utmost ingenuity to elude the obstacles which were interposed by his parents and governor to prevent him from acquiring the elementary notions of mathematics and astronomy. By placing the hinge of a common compass near his eye, he contrived to guess at the distances of the planets from the stars, and by this means, according to his own account, detected several errors in the Ephemerides of Stadius. By his persevering efforts he at last obtained the consent of his family to study according to his own inclinations; and from that moment he divided his time between the observation of the heavens, and chemical experiments. He visited the different cities of Germany where he hoped to meet with astronomers and skilful mechanicians, and was received with flattering attention by the landgrave of Hesse-Cassel, with whom he contracted an intimate friendship. On his return to Denmark he obtained from Frederick II. a grant of the small island of Huen, in the strait of Sunda, together with a pension and some presents, by means of which, and an expenditure of 100,000 crowns of his own patrimony, he was enabled to build the castle of Uraniburg, and procure a magnificent collection of the largest and most accurate instruments which could then be constructed. In this celebrated retreat he passed twenty-five years, actively employed in making observations, and attracting by his discoveries the attention of the learned throughout Europe. On the death of his protector Frederick he fell under the displeasure of the government, and a storm of persecution was raised against him, from causes which he has not explained, by a minister named Walckendorp, who, on this account, has been devoted by Lalande to the infamy and execration of all ages. He was deprived of his pension, compelled to leave the castle of Uraniburg, and to banish himself from Denmark. He retired first to Wandesburg, near Hamburg; he afterwards sought an asylum in Bohemia, and ultimately settled at Prague under the protection of the emperor Rudolph II. Here he resumed his observations, assisted by the illustrious Kepler and Longomontanus. The causes of his exile are involved in mystery; but to whatever it was owing, it turned out fortunate for the progress of astronomy. Had he remained in his island, his observations would not probably have fallen into the hands of Kepler, and the discovery of the laws of the planetary motions might have been deferred to another age. He died at Prague on the 24th of October 1601.

As an indefatigable and skilful observer, Tycho is justly considered as far superior to any astronomer who had preceded him since the revival of the science in Europe. His ample fortune gave him the means of procuring the best instruments which the age could produce; and by his ingenuity and persevering application, he was admirably qualified to employ them to the best advantage. He computed the first table of refractions, and if it extended only to 45°, the reason was, that the effects of refraction, at a higher altitude, were altogether insensible to his instruments. His solar tables were brought to so great a degree of exactness, that he affirms he could never detect an error in them exceeding a quarter of a minute; but there is reason to suspect some exaggeration in this statement, particularly as Cassini, a century after, with much better means, could scarcely answer for errors of a whole minute. He contributed greatly to the improvement of the lunar tables, and detected a considerable inequality in the moon's motion in longitude, to which he gave the name of the *Variation*, by which it has ever since been distinguished. He also discovered an equation in latitude similar to the evection which had been observed by Hipparchus, and fixed its amount with great accuracy. He remarked the fourth inequality of the moon in longitude, although he failed in his attempt to ascertain its amount, or assign its law. He represented the inequalities of the motions of the nodes, and in the inclination of the lunar orbit, by the motion of the pole of that orbit in a small circle round the pole of the ecliptic. He demonstrated that the region of the comets is far beyond the orbit of the moon, and determined the relative and absolute positions of 777 fixed stars with a scrupulous attention, which gave his catalogue an immense superiority over those of Hipparchus and Ulugh Beigh; and he left to his successors a regular series of observations on the planets, amassed for the purpose of establishing the truth of his own system, but of which Kepler made a better use by employing them to establish the system of Copernicus.

These are some of the important benefits which resulted to astronomy from the labours of Tycho. As a philosopher he ranks low. Alchemy and judicial astrology, in the reveries of which he was a firm believer, engrossed as much of his attention as astronomy. Yet his errors, or rather weaknesses, ought to be viewed with indulgence. He was seated, to use the simile of Bailly, on the confines of two ages; partaking of the darkness which preceded, and the light which came after him. He rejected the simple system of Copernicus, and, whether from participating in the religious scruples of his age, or from the

ambition of appearing as the author of a new system, he restored to the earth its immobility, and placed it in the centre of the motions of the sun and moon. The Tychonic system was an unsuccessful attempt to reconcile the incongruous hypotheses of Ptolemy and Copernicus. It never enjoyed any real estimation; and its followers were only found among those who dreaded the anathemas of the church, or who, belonging to some university or religious corporation, were deprived of the liberty of expressing their real opinions.

Longomontanus, born 1562, died 1647.

Tycho was assisted in his observations at Huen, during eight years, by Longomontanus, who afterwards became professor of the higher mathematics at Copenhagen. This astronomer composed a large work, entitled *Astronomia Danica*, in which he deduced the elements of the different theories from the observations made at Uranibourg, and gave formulæ for computing the planetary motions, according to the three systems of Ptolemy, Copernicus, and Tycho.

Kepler born 1571, died 16[illegible].

The great mass of accurate observations accumulated by Tycho furnished the materials out of which his disciple Kepler may be said to have constructed the edifice of the world. This great man, the true founder of modern astronomy, was born at Wiel, in the kingdom of Wurtemberg, on the 27th of December 1571. He studied philosophy at Tubingen, and was instructed in mathematics and astronomy by Mœstlin, whose name deserves a place in the history of science, on account of his having been one of the first who had the courage to adopt and to teach the system of Copernicus. The philosophical mind of Kepler, disgusted with the improbabilities and absurdities of the ancient system, received with transport the novel doctrines explained by Mœstlin. The appointment of mathematician to the emperor, which he procured on the death of Stadius, confirmed him in the resolution which he had taken to devote himself to astronomical pursuits; and the energy of his character enabled him in a very short time to make himself thoroughly master of the different hypotheses and principal discoveries which had been made prior to his time. In the year 1596 he published a *Prodromus* of Dissertations on the properties and causes of the celestial orbits, which procured him the friendship of Tycho, and an invitation to take part in the observations and researches of that great astronomer at Prague. On the death of Tycho, which happened soon after, Kepler obtained possession of his invaluable collection of observations, and was charged with the task of completing and publishing the *Rudolphine Tables*.

During his short residence with Tycho, Kepler learned to check the fanciful suggestions of his brilliant imagination, and to draw his conclusions from observations alone, by rigorous and patient induction. The observations of the Danish astronomer had furnished him with the means of establishing with certainty the truth or inaccuracy of the various hypotheses which he successively imagined; and the diligence with which he laboured in comparing and calculating these observations during 20 years, was finally rewarded by some of the most important discoveries which had yet been made in astronomy. Deceived by an opinion which had been adopted by Copernicus, and had never been called in question by the ancients, that all the celestial motions are performed in circles, he long fruitlessly endeavoured to represent, by that hypothesis, the irregular motions of Mars; and after having computed with incredible labour the observations of seven oppositions of that planet, he at length succeeded in breaking down the barrier which had so long obstructed the progress of knowledge, and found that the motions could only be accurately represented by supposing the planet to move in an ellipse, having the sun in one of its foci. Having arrived at this important result, he next proceeded to consider the angular motion of the planet, and finding that it was not uniform in respect of any point situated within the orbit, he concluded that the uniform motion, till then universally received as an axiom, was a vain chimera, which had no existence in nature. He perceived, however, that the areas described by the radius vector of the planet, at its greatest and least distances, were equal in equal times; and subsequent observations enabled him to demonstrate that this equality extended to every point of the orbit. It was therefore discovered that Mars moves in an elliptic orbit, of which the sun occupies a focus, and in such a manner, that the area described by a line drawn from the centre of the planet to that of the sun is always proportional to the time of description. The same conclusions he found to be true in respect of the orbit of the earth; and therefore he could no longer hesitate to extend them by analogy to the other planets. These are two of the three general principles which are known by the name of the *Laws of Kepler*.

It was some years later before Kepler arrived at the knowledge of the analogy which subsists between the distances of the several planets from the sun, and the periods in which they complete their revolutions. To the discovery of this analogy he attached the greatest importance, and regarded all his other labours as incomplete without it. After having imagined numberless hypotheses, it at last occurred to him to compare the different powers of the numbers which express the distances and times of revolutions; and he found, to his infinite satisfaction, that the squares of the periodic times of the planets are always in the same proportion as the cubes of their mean distances from the sun. This is the third law of Kepler. He demonstrated it to be true of all the planets then known. It has been found to be equally true in regard to those which have been since discovered, and likewise to prevail in the systems of the satellites of Jupiter and Saturn. It is indeed, as can be shown mathematically, a necessary consequence of the law of gravitation, directly as the masses, and inversely as the squares of the distances.

By these brilliant discoveries, the solar system was reduced to that degree of beautiful simplicity which had been conceived by Copernicus, but from which that great astronomer had found himself constrained to depart. The sun could not occupy the common centre of the circular orbits, but his place is in the common focus of the elliptic orbits of all the planets; and it is to this focus that every motion is to be referred, and from which every distance is to be measured. The discovery of the elliptic motion, of the proportionality of the areas to the times, and the method of dividing an ellipse, by straight lines drawn from the focus to the periphery, into segments having a given ratio, formed the solution of a problem which had been the constant object of the labours of all astronomers from Ptolemy to Tycho, namely, to assign the place of a planet at any instant of time whatever. The tables which he computed for the elliptic motions form the model of those in present use. Some additions have been made in consequence of the perturbations, which the geometry of Kepler was inadequate to estimate, and which were only partially detected by the genius of Newton. It has been considered matter of surprise that Kepler did not think of extending the laws of the elliptic motion to the comets. Prepossessed with the idea that they never return after their passage to the sun, he imagined that it would only be a waste of time to attempt the calculation of the orbits of bodies which had so transitory an existence. He supposed

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The observations of eclipses had formed the principal object of the earliest astronomers, but it was Kepler who first showed the practical advantages which may be derived from them, by giving an example of the method of calculating a difference of meridians from an eclipse of the sun. The method extends to occultations of the stars, and is deservedly considered as the best we possess for determining geographical longitudes and correcting the tables. He composed a work on optics, replete with new and interesting views, and gave the first idea of the telescope with two convex glasses, which has since been advantageously substituted for that of Galileo. Prompt to seize every happy idea of his contemporaries, he perceived with delight the advantages which practical astronomy would derive from the new invention of the logarithms, and he immediately constructed a table, from which the logarithms of the natural numbers, sines, and tangents could be taken at once.

Kepler was not merely an observer and calculator; he inquired with great diligence into the physical causes of every phenomenon, and made a near approach to the discovery of that great principle which maintains and regulates the planetary motions. He possessed some very sound and accurate notions of the nature of gravity, but unfortunately conceived it to diminish simply in proportion to the distance, although he had demonstrated that the intensity of light is reciprocally proportional to the surface over which it is spread, or inversely as the square of the distance from the luminous body. In his famous work *De Stella Martis*, which contains the discovery of the laws of the planetary motions, he distinctly states that gravity is a corporeal affection, reciprocal between two bodies of the same kind, which tends, like the action of the magnet, to bring them together, so that when the earth attracts a stone, the stone at the same time attracts the earth, but by a force feebler in proportion as it contains a smaller quantity of matter. Further, if the moon and the earth were not retained in their respective orbits by an animal or other equipollent force, the earth would mount towards the moon one fifty-fourth part of the interval which separates them, and the moon would descend the fifty-three remaining parts, supposing each to have the same density. He likewise very clearly explains the cause of the tides in the following passage. "If the earth ceased to attract its waters, the whole sea would mount up and unite itself with the moon. The sphere of the attracting force of the moon extends even to the earth, and draws the waters towards the torrid zone, so that they rise to the point which has the moon in the zenith." It is not difficult to imagine how much these views must have contributed to the immortal discovery of Newton.

It is afflicting to consider how frequently the just rewards of true merit are usurped by charlatanism and pretension. While the fire-eaters and astrologers of Rudolph were basking in the sunshine of imperial favour, Kepler, from whose labours the sciences derived the most signal benefits, passed his life in extreme indigence. Born without fortune, the only revenue he possessed, and out of which he had to maintain a numerous family, arose from the precarious produce of his writings, and his pension of mathematician to the emperor,—a pension which, owing to the calamities of the times, was seldom duly paid. On this account he was obliged to prefer frequent solicitations, and undertake long journeys, whereby he lost his time, always precious to genius, and exhausted his mind in anxiety. He died on the 15th of November 1630, at Ratisbon, whither he had gone to solicit the arrears that were due to him. In the present century a marble monument has been erected to his memory by an enlightened prince, Charles of Alberg. It contains his bust and the ellipse of Mars; a monument more glorious and more imperishable than brass or marble.

Contemporary with Kepler was the illustrious Galileo, whose discoveries, being of a more popular nature, and far more striking and intelligible to the generality of mankind, had a much greater immediate effect on the opinions of the age, and in hastening the revolution which was soon about to change the whole face of physics and astronomy. Galileo-Galilei, a Florentine patrician, was born at Florence in the year 1564. He passed his youth at Venice, where he continued till he was appointed to a professor's chair at Padua. After a residence of eighteen years in that city, he was induced to remove to Pisa by Cosmo II., who assigned him a pension, and conferred on him the title of his first mathematician. While residing at Venice, he heard it reported that Metius, a Dutch optician, had discovered a certain combination of lenses, by means of which distant objects were approximated to the sight. This vague and scanty intelligence sufficed to excite the curiosity of Galileo, who immediately set about inquiring into the means whereby such an effect could be produced. His researches were attended with prompt success, and on the following day he had a telescope which magnified about three times. It was formed by the combination of two lenses, a plano-convex and plano-concave, fitted in a leaden tube. In a second trial he obtained one which magnified seven or eight times; and subsequent essays enabled him to increase the magnifying power to 32 times. On directing his telescope to the moon, he perceived numerous inequalities on her surface, the diversified appearances of which led him to conclude almost with certainty that the moon is an opaque body similar to the earth, and reflecting the light of the sun unequally, in consequence of her superficial asperities. The planet Venus exhibited phases perfectly similar to those of the moon. These phases had been formerly announced by Copernicus as a necessary consequence of his system; and the actual discovery of their existence made it impossible to doubt of the revolution of Venus round the sun. He detected the four satellites or moons of Jupiter, and, in honour of his patron, gave them the name of the *Medicean Stars*. The discovery of these little bodies circulating round the huge orb of Jupiter afforded him a strong analogical proof of the annual revolution of the earth, accompanied by its moon. He perceived spots on the disk of the sun, from the motions of which he concluded the rotation of that body about its axis in the space of 27 days. The singular appearances of Saturn were beheld by him with no less pleasure than astonishment. His telescope was not sufficiently powerful to separate the ring from the body of the planet; and to explain the appearances he supposed Saturn to be composed of three stars almost in contact with one another. These discoveries proved that the substances of the celestial bodies are similar to that of the earth, and demolished the Aristotelian doctrine of their divine essence and incorruptible nature. They enlarged the ideas of mankind respecting the planetary system, and furnished the most convincing arguments in favour of the doctrines of Copernicus.

Galileo, born 1564, died 1642.

The discoveries of Galileo excited the envy of his

contemporaries, and stirred up against him a persecution which embittered the last days of his life. The motion of the earth, which he had proved so triumphantly, was considered contrary to many express declarations of Scripture; it was also considered as a heresy in the schools, where the doctrines of Aristotle were followed with implicit submission. In defending the Copernican system, Galileo had incurred the bitterest resentment, both of theologians and peripatetics. His great reputation, his title of professor and first mathematician, gave them reason to dread that the new doctrines, recommended by such an advocate, would spread too rapidly, and finally overthrow the altars of Aristotle. They therefore combined to check their progress, and to procure the ruin of Galileo by injurious representatives to the Grand Duke and the court of Rome. Soon after his first telescopic discoveries he was cited to appear before the Inquisition, and a promise extorted from him that he would never, either by word or writing, support the opinion of the motion of the earth. But in a great mind the love of truth is the most imperious of all passions, and cannot be restrained by the frowns of despotism, or the persecution of a fanatical tribunal. The evidences of the motion of the earth burst forth from every point of the heavens; and Galileo, in his celebrated *Dialogues* on the system of the world, exposed them in so clear and forcible a manner, that, although he appeared to put them forth for the purpose of refuting them, it was not difficult to perceive that he regarded them as complete and indubitable. For this relapse into heresy he was again brought before the tribunal of the Inquisition, and, in the seventieth year of his age, condemned formally to retract and abjure the doctrine of the earth's motion, and to be imprisoned during the pleasure of the Inquisition. This scandalous proceeding has called forth the indignant reprobation of every lover of truth and freedom. "What a spectacle," exclaims Bailly, "an old man, whose hairs were blanched with study, watchings, and benefits to mankind, on his knees before the sacred Scriptures, abjuring the truth in the eyes of Italy, which he had enlightened, in opposition to the testimony of his conscience, and in spite of the manifestations given by nature through all her works."

The sentence passed on Galileo was not inflicted with great severity. At the end of a year the Grand Duke had the influence to procure his release from prison; but he was prohibited from returning to Florence, and obliged to confine himself to the Tuscan territory. He retired to the village of Arcetri, where he resumed his observations, and shortly afterwards discovered the libration of the moon. The satellites of Jupiter continued also to engage his attention, and he commenced a table of their motions, and pointed out the method of determining the longitude by means of their eclipses. The states of Holland, aware of the great benefit of his researches to commerce and navigation, sent two astronomers, Hortensius and Blaeu, to present him with a gold chain, and encourage him to persevere in his useful labours. A short time after receiving this honourable mark of esteem from a foreign country, Galileo suddenly became blind; and the task of forming the tables of the satellites was reserved for Cassini. He survived this misfortune only a few years, and expired in 1642, in the seventy-eighth year of his age.

Science is indebted to Galileo for two other discoveries of a different kind, less brilliant perhaps, but of far greater importance than those which we have yet enumerated. These are the isochronism of the vibrations of the pendulum, and the law of the acceleration of falling bodies. His telescopic discoveries could not have remained long unknown; in fact, with the exception of those of the phases of Venus, and of the triple form of Saturn, they were all fiercely disputed, even during his own lifetime. It is now universally admitted that he was the first who discovered the satellites of Jupiter, and the spots of the sun; but the very circumstance of other claimants to these discoveries having arisen, proves that they were within the reach of ordinary attention. No one ever thought of disputing with Kepler the discovery of the laws of the planetary motions. Those of Galileo required only eyes, and may be regarded as following of course from the discovery of the telescope; but his persecution, his condemnation, and his being compelled to retract and abjure a doctrine of which he had given the physical proof, inspire a hallowed interest in his history, and contributed much to the great reputation which he acquired throughout Europe.

Logarithms invented, 1614.

While astronomy was making these rapid advances in the hands of Kepler and Galileo, an event occurred in Scotland which contributed, though less directly, no less powerfully, to the acceleration of its progress. This was the invention of the logarithms by Lord Napier, baron of Merchiston; "an admirable artifice," says Laplace, "which, by reducing to a few days the labour of many months, doubles the life of the astronomer, and spares him the errors and disgust inseparable from long calculations; an invention of which the human mind has the more reason to be proud, inasmuch as it was derived exclusively from its own resources." It may be added, that without this, or some equivalent artifice, the computations rendered necessary by more correct observations would far exceed the limits of human patience or industry, and astronomy could never have acquired that precision and accuracy by which it is now distinguished above all the other branches of human knowledge.

Labours of different astronomers.

The same epoch presents to us a great number of excellent observers, who, although they did not produce any revolution in the state of astronomy, still rendered it useful service. Scheiner is celebrated for his observations on the solar spots, and his disputes with Galileo. John Bayer of Augsburg published a description of the constellations, accompanied by maps, in which the stars are marked by a Greek letter; a simple idea, which has been universally adopted. Lansberg, a Flemish mathematician, published in 1632 a set of astronomical tables, which, though filled with inaccuracies, rendered good service to science by apprizing Horrox of the transit of Venus over the sun's disk, which that young astronomer and his friend Crabtree had the satisfaction of observing on the 24th of November 1639. They were the first who ever witnessed that interesting but rare phenomenon. Snellius is celebrated for his measure of the earth. Gassendi, who had the merit, along with Descartes, of hastening the downfall of the Aristotelian philosophy in France, made some useful observations, particularly one of a transit of Mercury in 1631. His works, which fill six folio volumes, abound with curious and useful researches. Riccioli, a Jesuit, born at Ferrara in 1598, contributed to the progress of astronomy, not so much by his own discoveries, as by collecting and rendering an account of those of others. He rejected the system of Copernicus, and was more zealous in maintaining the doctrines of the church than in investigating nature; but his works form a vast repertory of useful information. His *Novum Almagestum* is a collection of the observations, opinions, and physical explanations of the phenomena, together with all the methods of computation then known. He was assisted in his labours by Grimaldi, who discovered the inflection of light, and gave the names to the principal spots of the moon which are now used by astronomers.

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Hevelius, born 1611, died 1687.

The most accurate observations that were ever made prior to the adaptation of the telescope to astronomical instruments were those of Hevelius, a rich citizen of Dantzic, who devoted his life and a large fortune to the service of astronomy. Having fitted up an observatory, and furnished it with the best instruments which could be procured, he commenced a course of observations, which he followed assiduously upwards of forty years. In his *Selenographia* he has given an accurate description of the face and spots of the moon, accompanied with excellent delineations of her appearance in her different phases and librations. The idea of making drawings of the different phases of the moon had previously occurred to Gassendi and Peiresc, but they had not been able to execute the project; indeed the difficulty attending it was such, that it occupied Hevelius, who was an excellent draughtsman, as well as observer, during a great number of years. Hevelius made an immense number of researches on comets; and finding that the observations could not be represented by rectilinear or circular orbits, he supposed them to move in parabolas. During a temporary absence from Dantzic, this indefatigable astronomer had the misfortune to lose, in a great fire which occurred in the city, his observatory, instruments, manuscripts, and almost the entire edition of the second volume of his *Machina Cœlestis*, which contained the results of his long labours and numerous observations. He was now in his old age, but his zeal did not give way under the terrible calamity. He patiently recommenced all his calculations, reconstructed tables of the sun, and prepared for publication his *Firmamentum Sobiescianum*, or celestial chart, which did not appear till after his death. Towards the latter part of his life, the use of telescopic sights began to be generally adopted. Hevelius, however, resisted the innovation, and continued to employ plain sights. This preference given to the ancient method by so skilful an observer induced Dr Halley to visit him at Dantzic, for the purpose of ascertaining, by a comparison of observations made at the same time and place, which of the two methods gave the most correct results. Dr Halley observed with the telescope, and Hevelius with his own instruments; but such was the dexterity he had acquired through long practice, that the difference of their observations seldom amounted to more than a few seconds, and in no case to so much as a minute. Notwithstanding this agreement, it is to be regretted that Hevelius did not adopt the new method; for, on account of the greater precision given to instruments by the use of the telescope, his observations, which were made without it, cannot now be admitted in the construction of tables, and consequently are for the most part useless to astronomy.

Huygens, born 1629, died 1695.

Few individuals have rendered more important services to science than Huygens. Born at the Hague in 1629, he studied geometry under Schooten, the commentator of Descartes, and gave early proofs of proficiency in that science by a treatise on the quadrature of the conic sections. Having passed into France, he studied law at the university of Angers; but his principal attention was directed to the physical sciences, particularly to optics. He employed himself in grinding and polishing lenses; and constructed a telescope of ten feet, with which he discovered one of the satellites of Saturn. His application of the pendulum to clocks deserves to be considered as one of the best gifts which genius has ever conferred on science. He seems to have conceived the idea of this application in 1656; and he presented the first description of the pendulum clock to the states of Holland in 1657. He endeavoured to make this invention subservient to the problem of the longitudes; and if his efforts were not attended with the desired success, it may be said, that without another invention, in which also he had a principal share, that of the spiral spring, the object would never have been accomplished so nearly as it was a hundred years later. By means of his excellent telescopes he discovered that the extraordinary appearance exhibited by Saturn was occasioned by a ring surrounding the body of the planet, and inclined to the ecliptic in an angle which he estimated at 21°. He published his observations on this planet in a work entitled *Systema Saturnium*, which still shows some traces of that species of reasoning from final causes which so greatly disfigures the writings of Kepler. For example, on discovering the satellite, he conceived that as the number of satellites now equalled the number of planets, it was in vain to look for more, the equality being necessary to the harmony of the system. He lived, however, to witness the discovery of four more satellites belonging to the same planet. Huygens was invited to settle in France by Colbert, the patriotic minister of Louis XIV., who assigned him a pension and a seat in the academy of sciences. He continued in that country till the revocation of the edict of Nantz in 1681, when he resigned his pension and retired to Holland. After this he contributed several papers to the *Philosophical Transactions*, and in 1690 published a treatise on light and gravitation. Geometry, mechanics, and optics, are indebted to the genius of Huygens for many important discoveries. His theorems on central forces, his researches on the doctrine of probabilities and continued fractions, and his theory of involutes and evolutes, raise him to the highest rank among the mathematicians of his age. He died on the 8th of June 1695, at the age of 66 years.

Telescopes applied to quadrants, 1667.

The application of telescopes and micrometers to graduated instruments forms an important epoch in the history of astronomy. This happy improvement was first brought into use by Picard in 1667. Morin, indeed, had applied a telescope to the quadrant so early as 1634, and *perceived* the stars in full day in 1635. In 1669 Picard began to observe the stars on the meridian in the daytime, with a quadrant, to which, in concert with Azout, he had applied an astronomical telescope having cross wires in its focus. Huygens invented the plate micrometer in 1650; Malvasia that with the fixed wires in 1662; and Azout that with the movable wire in 1666. (See Delambre, *Astronomie du Moyen Age*, p. 618. Note by Bouvard.) It is principally to the happy discoveries and ingenious inventions just referred to, and the fine application of the pendulum to clocks by Huygens in 1656, that we must attribute the rapid progress since made in practical astronomy, and the extreme precision of modern observations. Picard was also the first who introduced the modern method of determining the right ascensions of the stars, by observing their meridional passages, and employed the pendulum for that purpose. He likewise introduced the method of corresponding altitudes, and is entitled to be regarded as the founder of modern astronomy in France.

Roemer, the friend and pupil of Picard, discovered the progressive motion of light in 1675, and measured its velocity by means of the eclipses of Jupiter's satellites. He was the first who erected a transit instrument, which gave a new accuracy to observations of right ascension.

Dominic Cassini, born 162 died 171

The Royal Observatory of Paris was completed in 1670, and its direction intrusted to Dominic Cassini. This celebrated astronomer was born at Perinaldo, in the county of Nice, and educated in a college of the Jesuits at Genoa. He acquired an early passion for astronomical observations; and in 1644 was invited to Bologna by the marquis Malvasia, where, in 1650, he succeeded Cavalleri

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as professor of astronomy. In this situation he continued till 1669, when he went to Paris on the invitation of Louis XIV. He was naturalized in France in 1673, and continued in the charge of the observatory till his death, which happened in 1712.

Cassini enriched astronomy with a great number of curious observations and discoveries. He determined the motions of Jupiter's satellites from observations of their eclipses, and constructed tables of them, which were found to be remarkably exact. He observed that the ring of Saturn is double, and discovered four of the satellites of that planet. He also determined the rotation of Jupiter and Mars, and made a number of observations on Venus with the same view. He observed the zodiacal light, and made a near approximation to the parallax of the sun. We also owe to him the first table of refractions, calculated on correct principles; and a complete theory of the libration of the moon. Galileo had only observed the libration in latitude; Hevelius explained the libration in longitude, by supposing that the moon always presents the same face to the centre of her orbit, of which the earth occupies a focus. Cassini made the important remark, that the axis of rotation of the moon is inclined to the ecliptic, and that its nodes coincide with those of the lunar orbit, so that the poles of the orbit, ecliptic, and equator of the moon, are on the same circle of latitude, the pole of the ecliptic being situated between the other two. The greater number of these discoveries are, however, only of secondary importance; and it must be confessed that Cassini took no part in the great and permanent improvements which astronomy received in that age. He has, nevertheless, obtained an extraordinary reputation. Lalande remarks, that in his hands astronomy underwent the most signal revolutions, and that his name is, in France, almost synonymous with that of creator of the science. Delambre has, however, taken a different and far more accurate view of the real services of Cassini. "The revolution in Astronomy," this judicious critic observes, "was brought about by Copernicus, by the laws of Kepler, by the pendulum of Huygens, the micrometers of Azout and Picard, by the sectors and mural of Picard, and his method of corresponding altitudes, by the transit instruments of Roemer; and Cassini appears to us an entire stranger to all these innovations. He followed another route; he devoted a long life to painful observations, which at last deprived him of sight. Let us not refuse him the praise which he has so well merited, but let us reserve a place in our esteem for labours less brilliant perhaps, but of greater and more permanent utility, and which evince at least equal talent and sagacity."

Maraldi.

Cassini was assisted in his observations by his nephew, James Philip Maraldi, who determined the regression of the nodes, and the progressive motion of the apsides of the orbit of Jupiter. This astronomer also corrected the theory of Mars, and observed the sun's parallax. He rejected the hypothesis of the progressive motion of light, as being insufficient to explain the inequalities of Jupiter's satellites; and he conceived the design of forming a new catalogue of the stars, which, however, was never executed. He died in 1729.

Progress of science in the 17th century.

There is no period in the history of mankind so distinguished by great and important discoveries, or so remarkable for the rapid development of the human intellect, as the seventeenth century. We have already noticed the invention of the pendulum, and its application to regulate the motion of time-keepers; of the telescope, and some of the phenomena of the new worlds it has exposed to view; of the logarithms, by which computations are so much abridged; and of the mechanical contrivances for measuring minute angles in the heavens. The same century witnessed the application of algebra to geometry, the discovery of the laws of the planetary motions, of the infinitesimal calculus, the acceleration of falling bodies, the sublime theory of central forces, and the great principle of gravitation which connects the celestial orbs, and regulates the motions which it had been the business of the astronomer to observe since the earliest ages of the world. The different steps which conducted to this important discovery, and the immediate consequences deduced from it by its immortal author, are so fully developed in the admirable Dissertation on the Progress of the Physical Sciences, in this Encyclopædia, that it is unnecessary to enter into any detail respecting them here; we may only remark, that if observation has furnished the data for the discovery of the mechanical principle and primordial laws of the universe, the knowledge of these laws has been, in turn, of the most essential service to observation, by guiding and directing it to its most important objects. Many of the inequalities of the planetary motions, in consequence of their minuteness and the slowness with which they vary, could not have been detected by observation; others might perhaps have been perceived, but we should still have been ignorant whether their constant accumulation might not ultimately change the state of the system, and, by destroying all confidence in the tables, demolish the fabric which had been reared at such a vast expense of time and labour. But when these inequalities are detected by theory, and separated from the mean motions with which they were blended, it becomes an object of the highest interest to confirm their existence by the most delicate and accurate observations. Hence, a more refined practice has constantly followed every theoretical discovery. Besides, it is the perfection of theory, and not the mere knowledge of isolated facts, which gives astronomy its greatest value in the eyes of the philosopher. Numerous and important as its applications are, they have but a subordinate interest, in comparison of the knowledge of those general laws to which every particle of matter in the universe is subject, and by the discovery of which man has penetrated so deeply into the mysteries of nature.

Discoveries of Newton, born 1642, died 1727.

By the discovery of the law of gravity Newton laid the foundations of physical astronomy; and by the consequences which he deduced from that law, proceeded far in the erection of the superstructure. He showed that the motions of all the bodies of the planetary system are regulated by its influence; he determined the figure of the earth on the supposition of its homogeneity; he gave a theory of the tides, discovered the cause of the precession of the equinoxes, and determined some of the principal lunar inequalities and planetary perturbations. Many of his theories were left in an imperfect state; for it is not in matters of science that it is given to the same individual to invent and bring to perfection: their complete development required that several subsidiary sciences should be farther advanced; but it has been the triumph of his system, that every subsequent discovery has only tended to strengthen and confirm it. This bright ornament of the human genius was born on the 25th of December 1642, the day of the death of Galileo, and died on the 20th of March 1727, in the 85th year of his age.

Flamsteed, born 1646, died 1719.

While physical astronomy was undergoing a complete revolution in the hands of Newton, the practical part was receiving great improvement from Flamsteed, the first astronomer royal, who conducted the Greenwich Observatory. This celebrated institution, from which so many important discoveries have emanated, was erected under the reign of Charles II. in 1675. Flamsteed was appoint-

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ed to it in 1676, and continued with indefatigable zeal to discharge the duties of the office during the long period of 33 years. In the course of this time he made an immense number of excellent observations, the results of which are given in the *Historia Cœlestis*, the first edition of which was published in 1712, at the expense of Prince George of Denmark, the husband of Queen Anne. The second appeared in 1723, some time after the death of the author, in three volumes folio. The first volume contains the observations which he made, first at Derby, and afterwards at Greenwich, on the fixed stars, planets, comets, spots of the sun, and Jupiter's satellites. The second volume contains the transits of the planets and stars over the meridian, and the places of the planets deduced from these observations. The third contains an historical notice, in which he gives a description of the instruments used by Tycho and himself; catalogues of fixed stars by Ptolemy, Ulugh Beigh, Tycho, the landgrave of Hesse, and Hevelius; together with the British Catalogue, containing the places of 2884 stars. The labours of Flamsteed were, however, confined entirely to the practical part of astronomy. He made no improvements in theory; but he is entitled to the merit of having been the first who brought into common use the method of simultaneously observing the right ascension of the sun and a star, a method by means of which the determination of the positions of the stars is reduced to the observation of meridional transits and altitudes. He was likewise the first who explained the true principles of the equation of time; and he improved the lunar tables by introducing into them the annual equation which had been suggested by Horrox. The *Atlas Cœlestis*, another posthumous work of Flamsteed, was published in 1753.

Halley, born 1656, died 1742.

Flamsteed was succeeded in the observatory by Dr Halley, a philosopher whose inventive genius and indefatigable activity rendered him one of the brightest ornaments of his country. Halley was the son of a wealthy citizen of London, where he was born on the 8th of November 1656. From his earliest years he applied himself with ardour to the study of mathematics and astronomy; and having procured a few instruments, he began to make observations, by which he was led to remark the inaccuracy of the tables of Jupiter and Saturn. In his 19th year he published a direct and geometrical method of finding the eccentricities and aphelia of the orbits of the planets; and in the year following he undertook a voyage to St Helena, with a view to form a catalogue of the stars in the southern hemisphere. The station was unfortunately chosen, for, owing to the incessant rains and foggy atmosphere of that island, he was able to determine the places of only 360 stars in the course of a whole year. He had, however, the satisfaction of observing a transit of Mercury over the sun's disk, a phenomenon which suggested to him the important remark, that the transits of the inferior planets might be advantageously employed in determining one of the most essential elements of the planetary system, viz. the parallax of the sun, and consequently the diameters of the orbits. The method has since been successfully employed in the case of Venus: the transits of Mercury, though much more frequent, are not so well adapted to the purpose. On his return from St Helena he was commissioned by the Royal Society to visit Hevelius at Dantzic, and determine, by a direct comparison of observations, the dispute which had arisen between that astronomer and Dr Hooke respecting the relative advantages of plain and telescopic sights. After this Halley for some time travelled on the Continent, and on his return to England devoted himself entirely to scientific pursuits. The fruits of his leisure soon began to appear in the multitude of treatises which he published from time to time in every department of the mathematical and physical sciences. The most important of those connected with astronomy was his *Synopsis Astronomiæ Cometicæ*,—a work abounding in profound and original views, and which, in respect of theory, formed perhaps the most remarkable accession to the science that had been made since the time of Kepler. In this work he revived an ancient opinion, that the comets belong to the solar system, and move in very eccentric orbits round the sun, returning after stated but long intervals. He also ventured to predict that the comet of 1681 would again return to its perihelion in 1759,—the first prediction of the kind that was verified. In 1720 Dr Halley was appointed to succeed Flamsteed in the Royal Observatory; and though now in the 64th year of his age, he undertook, with a view to improve the lunar theory, to observe the moon through a whole revolution of her nodes, erroneously supposing, that after such a revolution the errors of the tables would again appear in the same order. He was the first who, by a comparison of ancient and modern observations, remarked the acceleration of the mean motion of the moon, and thus called the attention of mathematicians to an important and curious phenomenon, the physical cause of which was at length detected by the powerful analysis of Laplace. He was also the first who pointed out the secular inequalities of Jupiter and Saturn, occasioned by their mutual perturbations,—a theory that formed the subject of several profound memoirs of Euler and Lagrange, and for the complete development of which astronomy is likewise indebted to Laplace. Besides these important discoveries in astronomy, the labours of Dr Halley also greatly contributed to the promotion of geometry and navigation. He undertook two long voyages, and traversed the Pacific Ocean to observe the deviations of the magnetic needle; and posterity will gratefully recollect that it was through his pressing solicitations that Newton consented to the publication of the *Principia*. In 1703 he succeeded Dr Wallis as professor of geometry at Oxford. He became secretary of the Royal Society in 1713, and died at Greenwich in 1742.

Bradley, born 169 died 176

The discoveries of Bradley, who succeeded Halley as astronomer royal, form a memorable epoch in the history of the science. This great astronomer was born at Sherborne in Gloucestershire in 1692, and acquired from his uncle, Mr Pound, an early taste for astronomical observation. He was destined for the church, and for some time held a curacy, which he resigned in 1721, on being appointed to succeed Keill as Savilian professor of astronomy at Oxford. His first essays indicated no extraordinary talent; but an opportunity having presented itself of engaging in more important researches, he embraced it with ardour; and by his sagacity and perseverance was conducted to two discoveries which have entirely changed the face of astronomy.

Discover of the ab ration of light.

A singular motion of the polar star had been observed by Picard, of which, however, that astronomer could neither assign the law nor give any satisfactory explanation. He only remarked that the inequality was annual, and amounted to about 40 seconds. Hooke, in 1674, a few years after the observations of Picard, imagined that he had discovered a parallax in some of the stars; and Flamsteed, following the ideas of Hooke, explained, by means of parallax, the minute changes of position which he had observed in Polaris and some circumpolar stars. Manfredi and Cassini demonstrated the error of Flamsteed, but were not more successful in their attempts to explain the motion in question. Samuel Molyneux conceived the idea of verifying all that had been said respecting the

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Discovery of the nutation; the terrestrial axis. Bradley, anxious to verify his ingenious theory, continued his observations, and soon felt the difficulty that had so much embarrassed Picard. The places of the stars, calculated according to his formula for the aberration, could not be reconciled with the observations. The errors continued to augment during nine years, after which they went on diminishing during the nine years following. This inequality, of which the period, like that of the nodes of the moon, was 18 years, was readily explained by supposing a slight oscillation of the earth's axis, occasioned by the action of the moon on the protuberant parts surrounding the equator of the terrestrial spheroid. After assiduously observing its effects during twenty years, Bradley found that the phenomena could be accurately represented by giving the pole of the equator a retrograde motion about its mean place in an ellipse whose axes are 18″ and 16″, and completing its revolution in the period of 18 years. This result was communicated to the Royal Society in 1748. To these two grand discoveries of Bradley, the aberration and nutation, modern astronomy is wholly indebted for all its accuracy and precision; and, as Delambre remarks, they assure to their author a distinguished place, after Hipparchus and Kepler, above the astronomers of all ages and all countries.

Bradley was appointed astronomer royal in 1741, and from this time to the period of his death made an immense number of observations, which were presented by his heirs to the university of Oxford, on condition that they should forthwith be published. The first volume appeared only in 1798, edited by Dr Hornsby. The rest were committed to the care of the late Dr Abraham Robertson, and appeared in 1805. Dr Bradley was chosen a corresponding member of the Academy of Sciences in 1748. In 1752, twenty-four years after his great discovery of the aberration of light, he was admitted into the Royal Society. He died on the 13th of July 1762, in the 70th year of his age.

While England was deriving so much glory from the brilliant discoveries of Bradley, France produced a multitude of excellent astronomers, by whose successful labours every department of the science was signally promoted. Among these Lacaille is pre-eminently distinguished, both by the variety and importance of his observations, and the indefatigable zeal with which, during twenty-two years, he prosecuted the most laborious researches. He commenced his astronomical career in 1739, by assisting Cassini de Thury (grandson of the first Cassini) in the verification of the measurement of the meridian through France. In 1751 he undertook a voyage to the Cape of Good Hope, the primary objects of which were to determine the sun's parallax, by means of observations on the parallaxes of Mars and Venus, while similar observations were made in Europe; and to form a catalogue of the southern circumpolar stars. No undertaking for the benefit of science was ever more successfully executed. In the course of a single year, Lacaille, without assistance, observed upwards of ten thousand stars, situated between the tropic of Capricorn and the pole, and computed the places of 1942 of them; a labour which would scarcely be credited, if the details of his observations had not been published in the *Cœlum Australe Stelliferum*, a work which was given to the world in 1763. Our admiration of the rapid execution of this vast undertaking will be increased, when we consider, that during the same time he measured a degree of the meridian, and made numerous observations on the moon simultaneous with those of Lalande, who observed at Berlin, in order to determine the moon's parallax, by means of direct observations made at the extremities of a meridional arc of upwards of 85 degrees. Before his return to Europe, he visited the isles of France and Bourbon, where he measured the length of the pendulum, and made numerous remarks on the natural and civil history of those countries. Astronomy is likewise indebted to Lacaille for a table of refractions which he computed from a comparison of above 300 observations made at the Cape and at Paris. In 1757 he published his *Astronomiæ Fundamenta*, in which he gave rules and tables for computing the apparent motions of the stars, which continued to be employed till Lambert supplied the corrections depending on the nutation, and Delambre those depending on the aberration. To defray the expense attending the publication of this important work, which he distributed in presents to the different observatories and astronomers in Europe, he submitted to the drudgery of calculating ephemerides during ten years. Lacaille composed several elementary works for the use of the students in the college of Mazarin, where he occupied the chair of astronomy, and inserted a great number of memoirs in the volumes of the Academy of Sciences. This great astronomer, distinguished as much by the excellence of his moral qualities as his profound knowledge and indefatigable zeal, died suddenly in 1762.

Lacaille, born 1713, died 1762.

The Royal Observatory of Paris continued under the direction of the family of Dominic Cassini during 120 years. James Cassini, the second of that name, is principally known by a work on the magnitude and figure of the earth, and his *Elements of Astronomy*. He seems not to have duly appreciated the new discoveries which were daily making around him. His *Elements*, published in 1740, contains no mention of the aberration; and he adopted the opinion that the earth is elongated instead of being flattened at the poles. His son, Cassini de Thury, was chiefly occupied with the meridian, and the geometrical survey of France. The last astronomer of the family, the Count de Cassini, was obliged to resign the observatory at the revolution.

Cassini II. born 1677, died 1756.

The question of the figure of the earth furnished ample materials for the practical as well as the speculative as-

Measurement of the earth.

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tronomer during the last century. The results of the measurement of the meridian by Cassini were at variance with the theories of Newton and Huygens; and the Academy of Sciences resolved on making a decisive experiment by the actual measurement of the lengths of two degrees, one at the equator, and another in as high a latitude as could be reached. In the year 1735, three astronomers, Godin, Bouguer, and La Condamine, were commissioned by the French government to accomplish the first of these objects in Peru; and the year following, Maupertuis, Clairaut, Camus, and Lemonnier, went to Lapland to execute the second under the polar circle. Notwithstanding the greater difficulties they had to contend with, the first party were the most successful; but the result of both operations established the compression of the earth at the poles. Bouguer published the details of the Peruvian measurement in an admirable work on the *Figure of the Earth*, in which he has also inserted an account of a great number of experiments made by him in the same country to determine the length of the seconds' pendulum, and the effects of the attraction of mountains on the plumb-line. Bouguer is likewise the author of an excellent treatise on light. This accomplished mathematician and experimenter did not adopt the Newtonian theory of gravitation, but he was the last apostle of the Cartesian philosophy in the Academy of Sciences.

It would greatly exceed the limits of this article to give even an abridged account of the numerous observers who, about this period, contributed to the improvement of every department of practical astronomy. We must therefore content ourselves with merely noticing the names of some of the most distinguished, leaving the details of their labours to be given in the biographical articles interspersed throughout the work.

Delisle, born 1688, died 1768.

Delisle formed a school of astronomy in Russia, and has left a method of computing the heliocentric places of the sun's spots, and of Mercury and Venus in their transits over the sun's disk, and likewise of determining, by means of the stereographic projection, the directions of their path when they enter and leave the disk.

Lemonnier, died 1799.

Lemonnier introduced the discoveries of Bradley into his *Astronomical Institutions*, and was the instructor of Lacaille and Lalande. He published a *Histoire Céleste*, containing a collection of observations from 1666 to 1685, and a number of other works and memoirs connected with astronomy. He made an immense number of observations, but their accuracy is far inferior to those of Bradley.

Wargentin, born 1717, died 1783.

Wargentin, secretary of the Academy of Sciences of Stockholm, devoted the whole of his life to the correction of the tables of the satellites of Jupiter. The theory of the satellites was not then far advanced; but when theory failed him, he profited by the remarks of others and by his own reflections, and endeavoured by repeated trials to find empirical equations capable of conciliating the tables with the best observations. By confining himself almost exclusively to this subject, he acquired a high reputation, and was ranked among the first astronomers of an epoch which abounds in great names. His tables of the satellites have, on account of their superior accuracy, been employed in determining the masses, and other elements, which serve as the basis of the analytical theories.

Lalande, born 1732, died 1807.

One of the most celebrated astronomers of the last century was Lalande. He commenced his early career by a set of lunar observations at Berlin, undertaken simultaneously with those of Lacaille at the Cape, for the purpose of determining the moon's horizontal parallax. On his return to Paris he was received, though only twenty-one years of age, into the Academy of Sciences; and on the resignation of Delisle was appointed professor of astronomy in the college of France. By his extraordinary zeal, indefatigable activity, and the care which he took to have his name constantly before the public, Lalande soon became one of the most distinguished men of his day; but his reputation, acquired in a great measure from attention to subjects which had only an ephemeral interest, and not through any permanent or fundamental additions to science, has already begun to wane; and his works, many of which are of considerable utility, seem to have fallen into unmerited neglect. His character as an astronomer is fairly and impartially summed up by Delambre in the following terms:—"If Lalande did not renew the foundations of astronomical science, like Copernicus and Kepler,—if he did not, like Bradley, immortalize himself by two brilliant discoveries,—if he was not so learned and accurate a theorist as Mayer,—if he was not to the same degree as Lacaille an exact, expert, scrupulous, industrious, and indefatigable observer and calculator,—if he had not the constancy to attach himself, like Wargentin, to a single object, in order to become the first in a particular department,—and if, in all these respects, he was only an astronomer of the second rank,—he was the first of all as a professor. No one ever did more to propagate the knowledge and love of astronomy. It was his object to be useful and celebrated; and he succeeded, through his labours, his activity, his credit, and his solicitations: by means of a most extensive correspondence he incessantly laboured for the benefit of science: he even endeavoured to serve it after his death, by founding a medal, which the Academy of Sciences adjudges annually to the astronomer who has made the most interesting observation, or written the most useful memoir." (Delambre, *Astronomie du Moyen Age.*)

Maskelyne, b. 1732, d. 1811.

Bradley was succeeded in the Greenwich Observatory by Dr Bliss, who died in the course of a few years after his appointment. Dr Bliss was in turn succeeded by Dr Maskelyne, the late astronomer royal, under whose care the observatory maintained the high character which it acquired from the immortal labours of his illustrious predecessors. Dr Maskelyne began his astronomical career in 1761, when he was appointed to observe the transit of Venus at the island of St Helena, and endeavour to verify the existence of a small parallax of the star Sirius, which seemed to be indicated by the observations of Lacaille at the Cape. Unfortunately the state of the weather prevented him from observing the transit; and his observations on Sirius were abandoned in consequence of the discovery of a defect in the zenith sector which he had carried out with him for the purpose of making the observations in question. The main objects of his voyage were thus frustrated; but some indirect advantages resulted from it, which compensated in some measure for the disappointment. The attention of Ramsden was called to the sector, and a better method of constructing these instruments was devised. At St Helena he made several interesting observations on the tides, the variation of the compass, the moon's horary parallaxes, &c. In going out and returning home, he paid particular attention to the different methods of finding the longitude at sea, and practised that which depends on observations of the lunar distances from known stars, taken with a Hadley's sextant, or other reflecting instrument. He also composed a set of rules for the use of the seamen, which he published on his return, first in the *Philosophical Transactions*, and afterwards in the *British Mariner's Guide*. In the year 1765 he was appointed astronomer royal, and soon after recommended to the Board of Longitude the general adoption in the navy of the lunar method of finding the

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Herschel, born 1738, died 1822. Sir William Herschel, born in Hanover in 1738, has rendered his name immortal by the discovery of a new planet without the orbit of Saturn, and thereby doubling the ancient boundaries of the solar system. Having settled in England, at Bath, he began to devote his leisure to the construction of telescopes and the polishing of reflecting mirrors. Endowed with equal skill and patience, he soon obtained instruments superior to any that had been known before, by means of which he was led to the most brilliant discoveries that have been made in the heavens since the time of Galileo. Being employed in making a review of the sky with a powerful telescope, he perceived, on the 13th of March 1781, near the feet of Gemini, a star of the fifth magnitude, having a disk perfectly well defined, and differing in appearance from the other stars which afforded the same quantity of light. On observing it with a telescope whose magnifying power was 932, he perceived its diameter was enlarged, while that of the stars underwent no change. These circumstances were sufficient to draw his attention to the star, and nothing more was requisite to enable him speedily to discover that it had a slow motion. He at first supposed it was a comet, and acquainted Dr Maskelyne with the discovery. The circumstance was soon made known at Paris; and it was gradually perceived, that as the distance of the star did not sensibly vary, it was necessary to regard it as a seventh planet. Herschel, in honour of his royal patron, gave it the name of the *Georgium Sidus;* but the mythological appellation of Uranus has prevailed. On the 11th of January 1787 he discovered two satellites revolving round the new planet, and subsequently found that it was accompanied by four others. It was soon noticed that Uranus had been observed by Flamsteed, Mayer, and Lemonnier, who had each supposed it to be one of the fixed stars. Their observations enabled Delambre to correct the elements of the orbit, and calculate tables of its motion. By means of his powerful telescopes Herschel determined the figure and rotation of Saturn, discovered the parallel belts on his surface, and perceived that the ring was double. In 1789 he discovered two new satellites belonging to this planet, and revolving within the ring. From some appearances indicated by the fixed stars, Herschel was led to conclude that the whole solar system is in motion about some distant centre, and that its direction is at present towards the constellation Hercules,—a conclusion, however, which succeeding observations have not verified. His observations on nebulæ and double stars have opened up a new field of research, boundless in extent, and interesting by reason of the variety of the objects it presents to the attention of the observer. The extraordinary activity with which he pursued his favourite occupations is attested by 67 memoirs communicated from time to time to the Royal Society. A great part of these, however, is filled with speculations of no value to astronomy; and his taste was rather to observe astronomical phenomena than to engage in computations, or the more arduous and essential, though less fascinating, labours through which the science can be really benefited. In the course of the following chapters we shall have frequent occasion to allude to his discoveries, and his ingenious speculations concerning the constitution of the sun and the sidereal heavens.

Delambre, born 1749, died 1822. Few individuals have contributed so eminently to the perfection of modern astronomy as Delambre, the late perpetual secretary of the Academy of Sciences. The scientific life of this illustrious astronomer did not commence till he had attained his 40th year; but from that time till his death it was occupied by a series of unremitting labours to enlarge the boundaries, and ameliorate the practice and theory of the science. Associated with Mechain, he was employed during the troubles of the revolution in measuring the meridian from Dunkirk to Barcelona,—a labour which was prosecuted with admirable zeal in the face of innumerable difficulties, and even dangers of the most formidable kind. By an immense number of excellent observations he determined the constants which enter into the formulæ deduced from theory by the profound researches of Lagrange and Laplace, and also formed a set of tables much more exact than any that had appeared before them. His *Astronomie Théorique et Pratique*, in three quarto volumes, contains the best rules and methods which have yet been devised for the guidance of the practical astronomer; and his *Histoire*, in six large volumes 4to, gives an account of every successive improvement which has been made in the science, and a full abstract of every work of celebrity which has been written respecting it, since the first rude observations of the Greeks to the end of the last century. It is invaluable to the historian, and will ever remain a proud monument of the profound learning and laborious research of its author.

Piazzi, born 1746, died 1826. The observatory which was established at Palermo about the year 1790, under the active superintendence of Piazzi, holds a distinguished rank among the similar institutions of Europe. Piazzi, born in 1746, took the habit of the religious order of the *Theatins* at Milan, and finished his noviciate in the convent of St Anthony. Among his preceptors he had the advantage of counting Tiraboschi, Beccaria, Le Sœur, and Jacquier; and from these illustrious masters he speedily acquired a taste for mathematics and astronomy. After filling several professors' chairs in the colleges of the Jesuits at Rome and Ravenna, he was appointed in 1780 professor of the higher mathematics in the academy of Palermo. Here his first care was to reform the general system of education; and, by the alterations which he introduced, he contributed powerfully to dissipate the shades of ignorance, which, under the double influence of the Jesuits and the Inquisition, still lowered over the soil of Sicily. After having rendered this service to literature, he obtained from the prince of Caramanico, viceroy of the island, permission to found an observatory, and undertook a voyage to France and

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England, in order to provide the instruments necessary for the new establishment. Having procured a vertical circle, a transit, and some other instruments from Ramsden, he returned to Palermo and commenced his observations. His first care was to prepare a new catalogue of stars, the exact positions of which he justly considered as the basis of all true astronomy. In prosecuting this object he did not content himself with a single observation, but before he fixed the position of any star, observed it several times successively; and, by this laborious but accurate method, he constructed his first great catalogue of 6748 stars, which was crowned by the Academy of Sciences of France, and received with admiration by the astronomers of all countries. His constant practice of repeating his observations led to another brilliant result, the discovery of an eighth planet. On the 1st of January 1801, Piazzi, searching for the star 87 of the catalogue of Mayer, cursorily observed a small star of the eighth magnitude, between Aries and Taurus. On the following day he remarked that the star had changed its position, and accordingly supposed it to be a comet. He communicated his observations to Oriani, who, seeing that this luminous point had no nebulosity like the comets, and that it had been stationary and retrograded within comparatively small limits like the planets, computed its elements on the hypothesis of a circular orbit. He found that this hypothesis agreed with the observations, and other astronomers soon confirmed its accuracy. He gave the planet the name of *Ceres Ferdinandea*, in honour of Ferdinand, king of Naples, in whose dominions it was discovered, and who proposed to consecrate the event by a gold medal, struck with the effigy of the astronomer; but Piazzi, nobly preferring the interests of science to vain honours which could add nothing to his glory, requested that the money destined for this purpose should be employed in the purchase of an equatorial, which was still wanting to his observatory. In 1814 he published a new catalogue, extended to 7646 stars,—a splendid monument of indefatigable zeal and activity. He made an uninterrupted series of solstitial observations from 1791 to 1816, for the purpose of determining the obliquity of the ecliptic, which, compared with those of Bradley, Mayer, and Lacaille, in 1750, give a diminution of 44″ in a year. Besides these labours, sufficient to occupy a life of ordinary industry, Piazzi composed a number of memoirs for the different societies of which he was a member, and was intrusted by the Neapolitan government with several important commissions respecting the public instruction and the regulation of weights and measures in Sicily. He died in 1826, after having bequeathed his library and all his instruments to the observatory at Palermo, and assigned a liberal annuity to be devoted to the instruction of young men who evince a decided taste for astronomy.

Discovery of the planet Ceres.

Discovery of Pallas, Juno, and Vesta.

The discovery of Ceres led to that of three other little planets, circulating at nearly the same distance from the sun,—a circumstance unique in the construction of the solar system. On account of the smallness of the new planet, and the nebulosity by which it is surrounded, the difficulty of finding it after it had for some time ceased to be observed, was so considerable, that Dr Olbers of Bremen was induced to examine, with particular care, the configurations of all the small stars situated in the vicinity of its path, in order to have the means of detecting it at any time with greater facility. While engaged in making observations for this purpose, he discovered, on the 28th of March 1802, and nearly in the same place where he had before observed Ceres, another planet similar in size and appearance, to which he gave the name of *Pallas*. The extraordinary circumstance of the discovery of two planets having nearly the same mean distance, and performing their revolutions nearly in the same time, led Dr Olbers to imagine that Ceres and Pallas were fragments of a larger planet which had revolved in the same place, and been shattered by some external force or internal convulsion. The immediate consequence of this hypothesis was the probability of the existence of other fragments of the original planet, hitherto undiscovered; and that if such fragments existed, the planes of their orbits would pass through the points in which the orbits of Ceres and Pallas intersect each other. This bold idea acquired some probability from the subsequent discovery of two other planets in the very quarter of the heavens to which Dr Olbers had directed the attention of astronomers. *Juno* was discovered by M. Harding of Lilienthal, on the 2d of September 1804; and *Vesta*, by Dr Olbers himself, on the 29th of March 1807. Diligent observation has not since added to their number.

Improvements in optical instruments.

Astronomy is a science which borrows the aid of several other sciences, with which its advancement is simultaneous. Instruments capable of appreciating or measuring the exceedingly minute quantities about which the observer now concerns himself, could only be produced in a very advanced state of mechanics. In the accurate graduation of large instruments, our English artists have long maintained an unrivalled superiority. Graham, a celebrated watch-maker, united to great dexterity in the mechanical arts a decided taste for observation; and the extraordinary improvements which he effected in the art of dividing form an era in the history of practical astronomy. The sector used by Bradley, in the observations which led to the discovery of the nutation, was of his construction, and he was also the inventor of the first compensation pendulum. Sisson, who succeeded him, maintained in this department the honour and pre-eminence of England. Bird was originally a weaver in Durham, and first gave proof of his mechanical genius by dividing dials for the watch-makers in a manner far superior to what had been commonly practised. He was employed by Sisson in the division of mathematical instruments, and recommended by that artist to Graham, who instructed him in his methods. He constructed the 8 feet quadrants employed in the Greenwich and Paris observatories, and another of 6 feet for Mayer at the observatory of Göttingen. Ramsden invented a machine for the more accurate division of instruments, on account of which he received a premium from the Board of Longitude. The mural quadrants of this artist were held in high estimation, and the transit instrument, sextant, and refracting micrometer, in passing through his hands, received considerable ameliorations. His astronomical instruments in general were considered the best that could be procured in Europe. Mr Troughton, who at present stands the foremost of our British opticians, has more than rivalled his predecessors. In the hands of this distinguished artist and astronomer, the division of instruments has been carried to a degree of precision and accuracy which probably will never be surpassed; while the great improvements he has introduced into the methods of constructing and mounting large instruments, and his ingenious inventions to elude natural obstacles, and guard against the accidental derangements from which it is impossible altogether to protect them, entitle him to the high place which he holds by universal consent among the most eminent philosophers and original mechanicians of the age. The numerous circles and other instruments of his manufacture, whether in the hands of private individuals or deposited in the different public observatories, are considered as the finest specimens of

Graham.

Sisson.

Bird.

Ramsden.

Troughton.

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Progress of Physical Astronomy.

Having now endeavoured to give an account of the labours of those astronomers who have principally contributed to make us acquainted with the state of the heavens, and the order and succession of the various phenomena they exhibit, we will conclude this part of the article by briefly adverting to the profound researches of some illustrious mathematicians who have developed the theory of Newton, and raised the fabric of physical astronomy to its present proud elevation.

Problem of the three bodies. Although the law of gravitation, as proposed by Newton, had from the first been admitted by all the most eminent astronomers of Britain, it was for a long time either opposed or neglected on the Continent. In fact, great improvements were required both in analysis and mechanics before it admitted of other applications than had been made by its great author, or could be regarded as any thing more than a plausible hypothesis. Newton demonstrated, that if two bodies only were projected in space, mutually attracting each other with forces proportional directly to their masses, and inversely to the squares of their distance, they would each accurately describe an ellipse round the common centre of gravity; and the spaces described by the straight line joining that centre and the moving body, would be proportional to the time of description, according to the second law of Kepler. But when it is attempted to apply Newton's law to the case of the solar system, great difficulties immediately present themselves. Any one planet in the system is not only attracted by the sun, but also, though in a greatly smaller degree, by all the other planets, in consequence of which it is compelled to deviate from the elliptic path which it would pursue in virtue of the sun's attraction alone. Now, the calculation of the effects of this disturbing force was the problem which geometers had to resolve. In its most general form it greatly transcends the power of analysis; but there are particular cases of it, and those too the cases presented by nature, in which, by reason of certain limitations in the conditions, it is possible to obtain an approximate solution to any required degree of exactness. For example, the Sun, Moon, and Earth form in a manner a system by themselves, which is very slightly affected by the aggregate attractions of the other planets. In the same way the Sun, Jupiter, and Saturn form another system, in which the motions are very little influenced by the action of any other body. In these two cases, then, the number of bodies to be taken into consideration is only three; and in this restricted form, the problem, celebrated in the history of analysis under the denomination of the *Problem of the Three Bodies*, is susceptible of being treated mathematically. With the hope of ameliorating the lunar tables, and of completing the investigations which Newton had commenced in the *Principia*, three distinguished geometers, Clairaut, D'Alembert, and Euler, about the middle of the last century, undertook, simultaneously, and without the knowledge of each other, the investigation of the problem of the three bodies, and commenced that series of brilliant discoveries which it is the glory of our own times to have seen completed.

Clairaut, born 1713, died 1765. Clairaut's solution of the problem of the three bodies was presented to the Academy of Sciences in 1747, and was applied to the case of the moon. From this solution he deduced with great facility, not only the inequality of the variation, which Newton had obtained by a more complicated, though at the same time a very ingenious method, but also the evection, the annual equation, and many other inequalities which Newton had not succeeded in connecting with his theory. It happened, however, curiously enough, that in the calculation of one effect of the disturbing force, namely, the progression of the moon's apogee, Clairaut was led into an error which produced a result that threatened to overturn the system of gravitation. The error consisted in the omission of some of the terms of the series expressing the quantity in question, which he wrongly supposed to have only an insensible value; and by reason of this omission, his first approximation gave only half of the observed progressive motion of the apogee. As this result was confirmed by D'Alembert and Euler, who had both fallen into the same error, it seemed to follow, as a necessary consequence, either that the phenomenon depended on some other cause than the disturbing force of the sun, or that the law of gravity was not exactly proportional to the inverse square of the distance. The triumph which this result gave to the Cartesians was not of long duration. Clairaut soon perceived the cause of his error; and by repeating the process, and carrying the approximations farther, he found the computed to agree exactly with the observed progression,—a result which had the effect of dissipating for ever all doubt respecting the law of gravity. The researches of Clairaut were followed by a set of lunar tables, much more correct than any which had been previously computed.

The return of the comet of 1682, which Halley had predicted for the end of 1758, or beginning of 1759, afforded an excellent opportunity for putting to the test both the theory of gravity and the power of the new calculus. Clairaut applied his solution of the problem of the three bodies to the perturbations which this comet sustained from Jupiter and Saturn, and, after calculations of enormous labour, announced to the Academy of Sciences, in November 1758, that the comet would return in the beginning of the following year, and pass through its perihelion about the 15th of April. It returned according to the prediction, but passed its perihelion on the 13th of March. The correction of an error of computation reduced the difference to nineteen days; and if Clairaut had been aware of the existence of the planet Uranus, he might have come still nearer the truth.

Besides these important researches on the system of the world, Clairaut composed an admirable little treatise on the figure of the earth, in which he gave the differential equations, till then unknown, of the equilibrium of fluids, whether homogeneous or heterogeneous, supposing an attractive force, following any law whatever, to exist among the molecules. He applied these equations to the earth; demonstrated that the elliptic figure satisfies the conditions of equilibrium; assigned the ellipticity of the different strata of which the earth may be supposed to be formed, together with the law of gravitation at the exterior surface. He likewise discovered the important theorem which establishes a relation between the oblateness of the terrestrial spheroid and the increase of gravitation towards the poles, on every supposition which can be imagined relative to the interior construction of the earth. By means of this theorem the ellipticity of the spheroid is deduced from observations of the lengths of the seconds' pendulum at different points of the earth's surface.

D'Alembert, born 1717, died 1783. D'Alembert, as has already been mentioned, presented a solution of the problem of the three bodies to the Academy of Sciences at the same time with Clairaut. In the year 1749 he published his treatise on the precession of the equinoxes,—a work remarkable in the history of analysis and mechanics. By means of his newly invented

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calculus of *Partial Differences*, and the discovery of a fertile principle in dynamics, he determined from theory the rate of the precession, which is nearly 50″ in a year. He also determined the nutation of the earth's axis, which had been discovered by Bradley, and assigned the ratio of the axes of the small ellipse which the true pole of the earth describes around its mean place, in the same time in which the nodes of the lunar orbit complete a revolution. The solution of this problem led to the determination of the ratio of the attractive forces of the sun and moon, which D'Alembert found to be that of seven to three very nearly; whence he inferred that the mass of the earth is 70 times greater than that of the moon. He proved likewise that the precession and nutation are the same in every hypothesis concerning the interior constitution of the earth. In 1754 he published the first two volumes of his *Researches on the System of the World.* In this work he applied the formulæ by which he had calculated the motions of the moon to the motions of the planets disturbed by their mutual attraction, and pointed out the simplest method of determining the perturbations of the motions of a planet occasioned by the action of its own satellites. D'Alembert also treated the subject of the figure of the earth in a much more general manner than had been done by Clairaut, who had confined his investigations to the case of a spheroid of revolution. He determined the attraction of a spheroid of small eccentricity, whose surface can be represented by an algebraic equation of any order whatever, and even supposing the spheroid to be composed of strata of different densities.

The works of D'Alembert, which are extremely numerous, abound generally in profound and original views, and contributed greatly to the advancement of the physical and mathematical sciences; but it is to be regretted that they are very frequently deficient in that perspicuity and order so necessary in abstruse speculations, and that the course of his reasoning can be followed with difficulty when he descends into the detail of analytical operations. He had a horror of calculation, and delighted in general considerations and speculations which frequently turned on matters of pure curiosity.

Euler, born 1707, died 1783.

The first memoir of Euler on the planetary perturbations was transmitted to the secretary of the Academy of Sciences in July 1747, some months before Clairaut and D'Alembert had communicated their solutions of the problem of the three bodies, and it carried off the prize which the academy had proposed for the analytical theory of the motions of Jupiter and Saturn. In this memoir Euler gave the differential equations of the elements of the disturbed planet, but suppressed the analysis by which he had been conducted to them. This analysis, however, he subsequently expanded in two memoirs, the first of which appeared in the Berlin Memoirs in 1749, and the second in those of Petersburg in 1750. Of these supplementary memoirs the first is remarkable on several accounts. It contains the first example of a method which has been fruitful of important consequences—namely, that of the variation of the arbitrary constants in differential equations, and the development of the radical quantity which expresses the distance between two planets in a series of angles, multiples of the elongations. The expressions which he gave for the several terms of this series were simple and elegant; and he demonstrated a curious relation subsisting among any three consecutive terms, by means of which all the terms of the series may be calculated from the first two. He was thus enabled to develop the perturbing forces in terms of the sines and cosines of angles increasing with the time, and thereby to surmount a very great analytical difficulty. Notwithstanding, however, the great merit of Euler's memoir, several of the formulæ expressing the secular and periodic inequalities were found to be inaccurate; and in order to procure a correction of these errors, and give greater perfection to so important a theory, the academy again proposed the same subject for the prize of 1752. This prize was also carried off by Euler. In the memoir which he presented on this occasion, he considered simultaneously the motions of Jupiter and Saturn, and determined, in the first instance, the amount of their various inequalities, independently of the consideration of the eccentricities of their orbits. Pushing the approximations farther, and having regard to the inequalities depending on the eccentricities, he arrived at a most important result relative to the periodic nature of the inequalities occasioned by the mutual perturbations of the planets; which laid the foundation of the subsequent discovery by Lagrange and Laplace of the permanent stability of the planetary system. He demonstrated that the eccentricities and places of the aphelia of Jupiter and Saturn are subject to constant variation, confined, however, within certain fixed limits, which it never exceeds; and he computed that the elements of the orbits of the two planets recover their original values after a lapse of about 30,000 years. In the year 1756 the Academy of Sciences crowned a third memoir of Euler on the same subject as the two former, namely, the inequalities of the motions of the planets produced by their reciprocal attractions. This memoir, analytically considered, is also of great value. The method which he followed and illustrated has since been generally adopted in researches of the same nature, and consists in regarding as variable, in consequence of the disturbing forces, the six elements of the elliptic motion, viz. 1*st*, the greater axis of the orbit, which, by the law of Kepler, gives the ratio of the differential of the mean longitude to the element of the time; 2*d*, the epoch of this longitude; 3*d*, the eccentricity of the orbit; 4*th*, the motion of the aphelion; 5*th*, the inclination of the orbit to a given fixed plane; and, 6*th*, the longitude of the node. By considering separately the variations introduced into each of these elements by the disturbing forces, Euler obtained some important results; but even in this memoir his theory was not rendered complete. He did not consider the variation of the epoch; and the expression which he gave for the motion of the aphelion did not include that part of it which depends on the ratio of the eccentricities of the orbits of the disturbed and disturbing planet. Besides, the present memoir, like the two former, contained several errors of computation, which, by leading to results known to be wrong, probably prevented the author himself from being aware of the full value of the ingenious methods of procedure which he had exposed. Euler concluded this important memoir by making an extended application of his formulæ to the orbit of the earth as disturbed by the action of the planets. From some probable suppositions, first employed by Newton, relative to the ratios of the masses of the planets to that of the sun, he determined the variation of the obliquity of the ecliptic at 48″ in a century,—a result which agrees well with observation. By this determination the secular variation of the obliquity of the ecliptic, which had been regarded by Lahire, Lemonnier, D'Alembert, and other eminent astronomers, as uncertain, was placed beyond doubt. The three memoirs which we have mentioned contain the principal part of Euler's labours on the perturbations; but physical astronomy is indebted to him for many other researches. He gave a solution of the problem of the precession of the equinoxes, and made several important steps in the lunar theory, with which he seems to have

History. occupied himself before he undertook the investigation of the planetary perturbations. In the year 1772, when entirely blind, he directed his son, Albert Euler, and two illustrious pupils, Krafft and Lexell, in the composition of a work of enormous labour on the same subject, which was undertaken with a view to discover the cause of the moon's acceleration. This work was concluded with a set of lunar tables deduced entirely from theory; but they were found to be far inferior to those of Mayer, and in some respects hardly equal to those of Clairaut.

The labours of Euler form an epoch in the history of the mathematical sciences. From the arithmetic of sines, and the simplest formulæ of trigonometry up to the variation of the arbitrary constants of differential equations, there is hardly an analytical theory which has not received extension or improvement from the creative powers of his great mind. The transactions of the Berlin and Petersburg Academies are filled with his inestimable productions; and if fecundity were not itself one of the attributes of genius, the number of the profound and laborious researches in which he was engaged would appear altogether incredible.

Mayer's lunar tables. The first theory of Euler formed the basis of the excellent lunar tables which were calculated by Tobias Mayer, and first published in the Memoirs of the Academy of Göttingen in 1753. Mayer was a skilful astronomer, and determined the co-efficients of the arguments of the different lunar inequalities from his own observations. He continued to correct and improve his tables till the time of his death, which happened in 1762, when a copy of them, containing his last corrections, was presented by his widow to the Board of Longitude in London. Bradley ascertained their accuracy by comparing them with a great number of his own observations, and made so favourable a report concerning them, that the Board of Longitude presented the widow of Mayer with a gratuity of L.3000. They were printed along with the author's lunar theory in 1765. Subsequently, the Board of Longitude directed Mason, who had been assistant to Bradley, to revise them, under the superintendence of Dr Maskelyne. Mason compared them with about 1200 of Bradley's observations; he corrected the co-efficients of Mayer, and introduced some new equations which had been indicated by that astronomer, but which he had considered as too uncertain, or of too small a value, to render it necessary to load his tables with them. Mayer's tables, thus corrected, were published in 1784, and for a long time continued to be the most accurate that had appeared.

The solution of the problem of the three bodies by Clairaut, D'Alembert, and Euler, gave rise to many other important works relative to the theory of the moon, into the merits of which, however, our limits will not permit us to enter. Thomas Simpson, Walmesley, Frisi, Lambert, Schulze, and Matthew Stewart, treated the subject with more or less success; but the complete explication of the theory of the lunar and planetary perturbations was reserved for two mathematicians, whose discoveries perfected the theory of gravitation, and explained the last inequalities which remained to be accounted for in the celestial motions,—we mean Lagrange and Laplace.

Lagrange, born '36, died '13. In the year 1764, the Academy of Sciences of Paris, which had so successfully promoted the great efforts that had already been made to perfect the theory of attraction, proposed for the subject of a prize the theory of the libration of the moon. This was considered as an appeal to the genius of Lagrange, whose splendid talents had suddenly shone forth in two profound papers on the theory of sound, inserted among the Memoirs of the Turin Academy, and in which the calculus of variations was first explained and made use of. Lagrange had the honour of carrying off the prize; but although he treated the subject in a manner altogether new, and with extraordinary analytical skill, he did not on this occasion arrive at a complete solution of the problem. In 1766 he obtained another prize for a theory of Jupiter's satellites. In the admirable memoir which Lagrange presented to the academy on this subject, he included in the differential equations of the disturbed motion of a satellite, the attracting force of the sun, as well as of all the other satellites, and thus, in fact, had to consider a problem of six bodies. His analysis of this problem is remarkable, inasmuch as it contained the first general method which was given for determining the variations which the mutual attractions of the satellites produce in the forms and positions of their orbits, and pointed out the route which has since been so successfully followed in the treatment of similar questions.

Discovery of the invariability of the mean distances. Of all the grand discoveries by which the name of Lagrange has been immortalized, the most remarkable is that of the invariability of the mean distances of the planets from the sun. We have already mentioned that Euler had perceived that the inequalities of Jupiter and Saturn, in consequence of their mutual actions, are ultimately compensated, though after a very long period. In prosecuting this subject, which Euler had left imperfect, Laplace had discovered that, on neglecting the fourth powers in the expressions of the eccentricities and inclinations of the orbits, and the squares of the disturbing masses, the mean motions of the planets, and their mean distances from the sun, are invariable. In a short memoir of 14 pages, which appeared among those of the Berlin Academy for 1776, Lagrange demonstrated generally, and by a very simple and luminous analysis, that whatever powers of the eccentricities and inclinations are included in the calculation of the perturbations, no secular inequality, or term proportional to the time, can possibly enter into the expression of the greater axis of the orbit, or, consequently, into the mean motion connected with it by the third law of Kepler. From this conclusion, which is a necessary consequence of the peculiar conditions of the planetary system, it results that all the changes to which the orbits of the planets are subject in consequence of their reciprocal gravitation, are periodic, and that the system contains within itself no principle of destruction, but is calculated to endure for ever.

In 1780 Lagrange undertook a second time the subject of the moon's libration; and it is to the memoir which he now presented to the Berlin Academy that we must look for the complete and rigorous solution of this difficult problem, which had not been resolved before in a satisfactory manner, either on the footing of analysis or observation. In the same year he obtained the prize of the Academy of Sciences on the subject of the perturbations of comets. In 1781 he published, in the Berlin Memoirs, the first of a series of five papers on the secular and periodic inequalities of the planets, which together formed by far the most important work that had yet appeared on Physical Astronomy since the publication of the *Principia*. This series did not, properly speaking, contain any new discovery; but it embodied and brought into one view all the results and peculiar analytical methods which had appeared in his former memoirs, and contained the germs of all the happy ideas which he afterwards developed in the *Mécanique Analytique*.

On account of the brilliant discoveries and important labours which we have thus briefly noticed, Lagrange must be considered as one of the most successful of those illustrious individuals who have undertaken to perfect the theory of Newton, and pursue the principle of gravi-

History.

tation to its remotest consequences. But the value of his services to science are not limited to his discoveries in physical astronomy, great and numerous as they were. After Euler, he has contributed more than any other individual to increase the power and extend the applications of the calculus, and thereby to arm future inquirers with an instrument of greater power, by means of which they may push their conquests into new and unexplored fields of discovery.

Laplace, born 1749, died 1827.

With the name of Lagrange is associated that of Laplace, whose rival labours divided the admiration of the scientific world during half a century. Like Newton and Lagrange, Laplace raised himself at an early age to the very highest rank in science. Before completing his 24th year, he had signalized himself by the capital discovery of the invariability of the mean distances of the planets from the sun, on an hypothesis restricted, indeed, but which, as we have already mentioned, was afterwards generalized by Lagrange. About the same time he was admitted into the Academy of Sciences, and thenceforward devoted himself to the development of the laws which regulate the system of the world, and to the composition of a series of memoirs on the most important subjects connected with astronomy and analysis. His researches embraced the whole theory of gravitation; and he had the high honour of perfecting what had been left incomplete by his predecessors.

Discovers the cause of the moon's acceleration.

Among the numerous inequalities which affect the motion of the moon, one still remained which no philosopher as yet had been able to explain. This was the acceleration of the mean lunar motion, which had been first suspected by Dr Halley, from a comparison of the ancient Babylonian observations, recorded by Hipparchus, with those of Albategnius and the moderns. The existence of the acceleration had been confirmed by Dunthorne and Mayer, and its quantity assigned at 10″ in a century, but the cause of it remained doubtful. Lagrange demonstrated that it could not be occasioned by any peculiarity in the form of the earth; Bossut ascribed it to the resistance of the medium in which he supposed the moon to move; and Laplace himself at first explained it on the supposition that gravity is not transmitted from one body to another instantaneously, but successively in the manner of sound or light. Having afterwards remarked, however, in the course of his researches on Jupiter's satellites, that the secular variation of the eccentricity of the orbit of Jupiter occasions a secular variation of the mean motions of the satellites, he hastened to transfer this result to the moon, and had the satisfaction to find that the acceleration observed by astronomers is occasioned by the secular variation of the eccentricity of the terrestrial orbit. This was the last celestial phenomenon which remained to be accounted for on the principle of gravitation.

Inequalities of Jupiter and Saturn.

Another discovery relative to the constitution of the planetary system, which does infinite honour to the sagacity of Laplace, is the cause of the secular inequalities indicated by ancient and modern observations in the mean motions of Jupiter and Saturn. On examining the differential equations of the motions of these planets, Laplace remarked, that as their mean motions are nearly commensurable (five times the mean motion of Saturn being nearly equal to twice that of Jupiter), those terms of which the arguments are five times the mean longitude of Saturn, minus twice that of Jupiter, may become very sensible by integration, although multiplied by the cubes and products of three dimensions of the eccentricities and inclinations of the orbits. The result of a laborious calculation confirmed his conjecture, and showed him that in the mean motion of Saturn there existed a great inequality, amounting at its maximum to 48′ 2″·3, and of which the period is 929 years; and that in the case of Jupiter there exists a corresponding inequality of nearly the same period, of which the maximum value is 19′ 46″, but which is affected by a contrary sign, that is to say, diminishes while the first increases, and *vice versa*. He also perceived that the magnitude of the co-efficients of these inequalities, and the duration of their periods, are not always the same, but participate in the secular variations of the elements of the orbits.

Figure of the earth.

The theory of the figures of the planets, scarcely less interesting than that of their motions, was also greatly advanced by the researches of Laplace. He confirmed the results of Clairaut, Maclaurin, and D'Alembert, relative to the figure of the earth, and treated the question in a much more general way than had been done by those three great mathematicians. From two lunar inequalities depending on the non-sphericity of the earth, he determined the ellipticity of the meridian to be $\frac{1}{306}$ very nearly.

Tides.

Newton, in the *Principia*, explained the cause of the phenomena of the tides, and laid the foundations of a theory which was prosecuted and extended by Daniel Bernoulli, Maclaurin, Euler, and D'Alembert; but as no one of these geometers had taken into account the effects of the rotatory motion of the earth, the subject was in a great measure new when it was taken up by Laplace in 1774. Aided by D'Alembert's recent discovery of the calculus of *Partial Differences*, and by an improved theory of hydrodynamics, he succeeded in obtaining the differential equations of the motion of the fluids which surround the earth, having regard to all the forces by which these motions are produced or modified, and published them in the Memoirs of the Academy in 1775. By a careful examination of these equations, he was led to the curious remark, that the differences between the heights of two consecutive tides about the time of the solstices, as indicated by Newton's theory, are not owing, as Newton and his successors had supposed, to the inertia of the waters of the ocean, but depend on a totally different cause, namely, the law of the depth of the sea, and that it would disappear entirely if the sea were of a uniform and constant depth. He also arrived at the important conclusion, that the fluidity of the sea has no influence on the motions of the terrestrial axis, which are exactly the same as they would be if the sea formed a solid mass with the earth. The same analysis conducted him to the knowledge of the conditions necessary to insure the permanent equilibrium of the waters of the ocean. He found that if the mean density of the earth exceeds that of the sea, the fluid, deranged by any causes whatever from its state of equilibrium, will never depart from that state but by very small quantities. It follows from this, that, since the mean density of the earth is known to be about five times greater than that of the sea, the great changes which have taken place in the relative situation of the waters and dry land must be referred to other causes than the instability of the equilibrium of the ocean.

Precession of the equinoxes.

Closely connected with the problem of the tides is that of the precession of the equinoxes, which also received similar improvements in passing through the hands of Laplace. He demonstrated, as has just been mentioned, that the fluidity of the sea has no influence on the phenomena of precession and nutation. He considered some of the effects of the oblate figure of the earth which had not been attended to by D'Alembert, and showed that the annual variation of the precession causes a corresponding variation in the length of the tropical year, which at present is about 9 or 10 seconds shorter than it was in the time of Hipparchus. He proved that the secular inequa-

History. lities of the motions of the earth and moon have no sensible effect in displacing the axis of the earth's rotation; and he determined the nutation of the lunar orbit corresponding to the nutation of the terrestrial equator.

Jupiter's satellites. Physical astronomy is also indebted to Laplace for a complete theory of the system of Jupiter's satellites, from which Delambre constructed a set of tables which represent the motions of these bodies with all desirable accuracy. And when to these numerous and most important researches we add the mathematical theories of molecular attraction, and the propagation of sound, together with many great improvements in analysis,—and reflect, besides, that he is the author of the *Mécanique Céleste*, the *Système du Monde*, and the *Théorie des Probabilités*,—we shall not hesitate to rank him next to Newton among the greatest benefactors of the mathematical and physical sciences.

By the brilliant discoveries of Laplace, the analytical solution of the great problem of physical astronomy was completed. The principle of gravity, which had been discovered by Newton to confine the moon and the planets to their respective orbits, was shown to occasion every apparent irregularity, however minute, in the motions of the planets and satellites; and those very irregularities which were at first brought forward as objections to the hypothesis have been ultimately found to afford the most triumphant proofs of its accuracy, and have placed the truth of the Newtonian law beyond the reach of all future cavil. Such is the state to which analysis has now attained, that the geometer embraces in his formulæ every circumstance which affects the motions or positions of the different bodies of the planetary system; and the conditions of that system being made known to him at any given instant of time, he can determine its conditions at any other instant in the past or future duration of the world. He ascends to remote ages to compare the results of his theories with the most ancient observations; he passes on to ages yet to come, and predicts changes which the lapse of centuries will hardly be sufficient to render sensible to the observer. But notwithstanding the proud elevation to which the theory of astronomy has been raised, it is still far from having reached the limit beyond which further refinement becomes superfluous. The masses of the planets, and some other elements, remain to be determined with still greater precision, by a diligent comparison of the analytical formulæ with good observations; and the labours of the geometer may still be beneficially employed in giving greater simplicity to the calculus, or in extending its power over subjects which have hitherto eluded its grasp. The recent discovery of two periodic comets completing their revolutions in comparatively short intervals of time, opens up an interesting field for speculation and research, and will doubtless be the means of throwing light over some curious, and as yet very obscure, points, respecting the appearances, motions, and physical constitution of those strange bodies.

In the other departments of the science, also, numerous questions still remain to be discussed, the solution of which will occupy and reward the future labours of the astronomer. The curious phenomena of double and multiple stars, some of which appear to form connected systems of bodies revolving about one another, or a common centre of motion,—the variable stars,—the proper motions of the stars,—the translation of the solar system in space,—the progressive condensation of nebulæ,—are subjects still in a great measure new; for it is only of late years that observers have begun to direct the requisite attention towards them, or indeed have been in possession of instruments of sufficient power and delicacy to observe and measure the minute changes which take place beyond the boundaries of our own system. The observations of some living astronomers, particularly of Mr Herschel and Mr South, have made known some important facts regarding the nebulæ and double-stars, and laid the foundations of interesting discoveries to be realized by their successors in future ages of the world. History.

Among the events auspicious to the future progress of astronomy in our own country, we cannot forbear to regard the establishment of the *Astronomical Society of London*, an association which, though it dates only from 1820, includes in its list of *Members* the names of the greater part of the most distinguished cultivators of the science in Europe. The society has already given the best proofs of its energy and usefulness, by the publication of a catalogue of the reduced places of 2881 of the principal stars visible above our horizon, and four splendid volumes of *Memoirs*, replete with information and remarks of the most useful kind to the observer. The number of public observatories recently established, or at present in a state of progress, in various parts of the country and its colonies, also holds out a cheering prospect to the friends of astronomical discovery. Nor if we turn our eyes abroad shall we perceive less reason for congratulation. The same zeal for extension and refinement is manifested in every country of Europe; and while some of the states, among which Prussia and Denmark deserve to be honourably mentioned, are gaining themselves glory by the encouragement they hold out to the cultivation of this department of science, the exertions of individual observers appear to increase in proportion as the field is narrowed by their success. Armed with instruments to which former times had nothing to compare, the astronomer of the present day not only anticipates a more perfect knowledge than he yet possesses of the nature and number of the bodies belonging to the solar system, but aspires to set at rest the disputed question of parallax, to determine the proper motions of the stars, and trace the effects of gravity in the remotest regions of the universe.

Such are the present prospects of astronomy. The mind delights to contemplate unlimited advancement in a walk in which its efforts have been so signally triumphant; yet in consequence of what has already been done, the future progress of the science must necessarily be slow; and it must be acknowledged that greater precision than has already been attained is unnecessary to navigation or geography, or any practical application of which astronomy admits. The future results of observation may add to the stock of speculative knowledge, but can only be remotely useful to mankind.

Works on the history of astronomy.

The following works may be consulted on the history of astronomy:—Riccioli, *Almagestum Novum*, Bononiæ, 1653, 2 vols. folio; Sherburn's *Translation of the Astronomicon of Manilius*, London, 1675; Weidler, *Programma de Veteris et Novæ Astronomiæ Discrimine*, Wittembergæ, 1720; Souciet, *Observations Mathématiques, Astronomiques*, &c. 1729, 2 vols. 4to. The second volume of this work, by Gaubil, contains a history of the Chinese Astronomy, with Dissertations. Weidler, *Historia Astronomiæ*, Wittemb. 1741; Idem, *Commentatio de Mechanica Astronomica Medii Ævi*, 1742; Long's *Astronomy*, London, 1742; Costard's *Letter to Martin Folkes concerning the Rise and Progress of Astronomy among the Ancients*, London, 1746; Foulques' *History of Astronomy*, London, 1746; Heathcote, *Historia Astronomiæ*, Cantab. 1747, 8vo; Esteve, *Histoire Générale et Particulière de l'Astronomie*, Paris, 1755, 3 vols. 12mo; Goguet, *Origine des Lois, des Arts, et des Sciences*, various editions; Jablonow, *De Astronomiæ Ortu ac Progressu*, &c. Romæ, 1763, 4to; Bailly, *His-*

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toire de l'Astronomie Ancienne et Moderne, 1775, 1779, 1782, 4 vols. 4to. This work has been published without the notes and calculations, in 2 vols. 8vo, Paris, 1805. Gentil, *Sur l'Astronomie des Indiens, Hist. Acad.*, Paris, 1772; Gaubil, *Histoire de l'Astr. Chinoise*, in the *Lettres Edifiantes et Curieuses*, tom. xxvi.; Bailly, *Traité de l'Astr. Indienne*, Paris, 1787, 4to; Playfair's *Remarks on the Astronomy of the Brahmins*, in the *Edinburgh Transactions*, republished in the 3d volume of his *Works; Asiatic Researches*, vols. ii. vi. viii.; Adam Smith's *Fragment on the History of Astronomy;* Lalande, *Astronomie*, Paris, 1792, 3 vols. 4to; Idem, *Bibliographie Astronomique, avec l'Histoire de l'Astronomie depuis* 1781 *jusques à* 1802; Vince's *Astronomy*, vol. ii. Cambridge, 1799; Kaestner, *Geschichte der Mathematik*, Göttingen, 1796; Schaubach, *Geschichte der Griechischen Astronomie bis auf Eratosthenes*, Göttingen, 1802, 8vo; Montucla, *Histoire des Mathématiques*, Paris, an 7, an 10 (1802), 2d edit. 4 vols. 4to; Laplace, *Exposition du Système du Monde*, and Pond's *Translation* of the same work; Small's *History of the Discoveries of Kepler*, 1803; Bossut, *Histoire Générale des Mathématiques*, Paris, 1810, 2 vols. 8vo; Voiron, *Histoire de l'Astronomie depuis* 1781 *jusques à* 1811, Paris, 1811, 8vo, a continuation of Bailly; Delambre, *Histoire de l'Astronomie Ancienne*, Paris, 1817, 2 vols. 4to; Idem, *Histoire de l'Astronomie du Moyen Age*, 1819, 4to; Idem, *Histoire de l'Astronomie Moderne*, 1821, 2 vols. 4to; Idem, *Histoire de l'Astronomie du xviii. Siècle*, 1827, 4to. These six volumes of Delambre's *Histoire* contain copious extracts of all the principal works which have been published on the subject of astronomy, interspersed with much enlightened criticism.

PART II.

THEORETICAL ASTRONOMY.

CHAP. I.

GENERAL PHENOMENA OF THE HEAVENS.

SECT. I.—*Of the Celestial Sphere.*

When a spectator on a clear evening directs his attention to the sky, he perceives a concave hemisphere studded with innumerable brilliant points, all which appear to move in parallel directions, constantly preserving the same distances and relative positions. New groups of stars incessantly follow one another, rising in the east, mounting to a certain height, and then gradually sinking till they disappear in the west. On turning his face towards the north he observes some groups of stars which remain visible during the whole night; wheeling round a certain fixed point, and describing circles of greater or less magnitude, according as they are at a greater or less distance from that point. The same phenomena are observed every successive night; and as the stars present always the same configurations, and succeed each other in the same order, the mind is irresistibly led to the hypothesis of the diurnal revolution of the whole heavens about a fixed axis. This hypothesis implies that the stars move in parallel planes, and that their mutual distances remain invariable. In order, however, to be assured that such is the case, it is necessary to have recourse to more accurate observations, and to refer their successive positions to something that is fixed,—to certain points or planes which do not participate in the general motion.

Horizon.

What is most obviously adapted for this purpose is the *Horizon*, or the plane which appears extended all round us, and bounded by a circle of which the eye of the spectator occupies the centre. Let the circle SENW (fig. 1) represent the horizon, C being the eentre or place of the observer. Suppose now that a star is observed to rise at a certain point of the horizon A, and, after tracing its circuit in the sky, to set at the point A′; suppose, also, that another star rises at B, and sets at B′; then, if the distances AB, A′B′ are measured by means of some angular instrument, it will be found that AB is equal to A′B′, and that this is the case with regard to any two stars whatever. Since therefore the arcs AB and A′B′ are equal, it follows that the chords A A′, B B′, joining their extremities, are parallel; whence we infer, that if two stars rise successively at the same point of the horizon A, they will also set at the same point A′, a circumstance which is of itself strikingly indicative of the uniformity of the motion of the celestial bodies.

Plate LXXIX. Fig. 1.

Cardinal points.

Through C let a perpendicular be drawn to the chord AA′, meeting the boundary of the horizon in S and N. These two points are the *South* and *North* points of the horizon; and another straight line drawn through C, parallel to A A′, will meet the horizon in E and W, the *East* and *West* points. The four together, namely, S, E, N, W, are called the four *Cardinal* points of the horizon. The horizontal circle is itself denominated the *Azimuth Circle*. Azimuth distances are measured from the North and South points, so that SA is the azimuth distance of a star's rising at A, and SA′ is that of its setting at A′. The complement of the azimuth, or its defect from a right angle, is called the *Amplitude*, which is consequently measured from the East and West points; thus the arc EA is the amplitude of a star's rising at A, or its *ortive* amplitude, and WA′ is that of its setting, or its *occasive* amplitude.

Azimuth.

Amplitude.

Conceive a straight line to pass through C, perpendicular to the horizon. This line, which is called the *Vertical*, will meet the visible hemisphere in a point directly above the observer, which is denominated the *Zenith;* the point diametrically opposite, in which the prolongation of the vertical meets the invisible hemisphere, is the *Nadir*. The plane determined by the vertical and the straight line NS is called the *Meridian*, because when the sun reaches it, he is equally distant from the points at which he rises and sets, or, it is mid-day. The great circle formed by the intersection of the meridian with the celestial sphere is the *Meridional* circle; it divides the sphere into the eastern and western hemispheres. Any circle passing through the Zenith and Nadir is called a *Vertical Circle;* that which intersects the meridional circle at right angles, or which passes through the points E and W, is called the *Prime Vertical*.

Zenith.

Nadir.

Meridian.

Vertical.

Fig. 2.

Let HPZH′ (fig. 2) represent a meridional circle passing through P, that point of the sphere which appears to remain immovable; and let Z be the zenith, and HH′ the horizon. Join PC′, and let it meet the circle in P′. The points P and P′ are denominated the *Poles* of the world, and the straight line PP′ is the *Axis* about which the whole heavens appear to revolve. Let also *uv*, H*g*, *kl*, ÆÆ, *g*′H′, be projections of the paths of different stars

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on the vertical plane PZH. One of the first circumstances which strikes the attention of the observer is the inequality of the times during which different stars continue visible above the horizon. A star which describes the circle ÆÆ continues visible during a shorter time than one which describes *kl*, and still shorter than one which moves in H*g*. It will be remarked, however, that the interval between two successive risings of the same star is always the same, in whatever point of the horizon it makes its appearance. Those which describe ÆÆ are peculiar in this respect, that the interval between their rising and setting is exactly equal to that between their setting and rising; hence the great circle which they describe is called the *Equator*, and when the sun describes that circle, the days and nights are exactly of the same length. In general, the time during which a star continues visible is greater in proportion as its path is nearer to the visible pole. Those, however, which describe the circle H*g*, or any other parallel, as *uv*, nearer to P, remain always above the horizon; hence such circles are called circles of *Perpetual Apparition*, and the stars describing them are called *Circumpolar Stars*.

Equat.

There are some other technical terms, chiefly employed in the old treatises of astronomy, to denote particular circles of the sphere. A *Secondary* to any great circle, is a circle passing through the poles of its primary: thus the meridian is a secondary to the horizon HH′, and to the equator ÆÆ′. The *Colures* are two secondaries to the equator, one of which passes through the equinoctial points, and is called the *Equinoctial Colure;* the other intersects the equator at the distance of 90° from the former, and is denominated the *Solstitial Colure*. The small circles parallel to the equator are simply termed *Parallels;* those which are parallel to the horizon are called *Almicantars;* and the different meridians are likewise termed *Hour Circles*.

Second. Aries.

Colures

Parallels. Almicantars.

The hypothesis of a spherical revolution implies, as has already been mentioned, that the stars move in parallel planes, or describe parallel circles round the pole. This point, in reference to any particular star, must be determined by observing whether its angular distance from the pole remains invariable during its whole revolution. Let Z (fig. 3) be the zenith, P the pole, and S the place of a star. The arcs PZ, ZS, PS, which join these points on the sphere, will form a spherical triangle, of which the sides PZ and ZS, or the distances of the pole and the star from the zenith, are given by direct observation. The angle PZS is also given in the same manner, for it is equal to the star's azimuth counted from the north point of the horizon. In the triangle ZPS we have therefore given the two sides ZP and ZS, together with the included angle PZS, from which data the polar distance PS is found by the following formula of spherical trigonometry:

Fig. 3.

$$\cos. PS = \sin. ZS \sin. ZP \cos. PSZ + \cos. ZS \cos. ZP.$$

In order to adapt this formula to logarithmic computation, an auxiliary angle φ may be assumed such, that $\tan. \varphi = \cos. PZS \tan. ZP$, by the substitution of which the formula becomes

$$\cos. PS = \frac{\cos. ZP. \quad \cos. (PZS - \varphi)}{\cos. \varphi};$$

from which the polar distance PS of the star can be easily computed.

On performing the computation for any particular star, PS is always found to be of a constant magnitude, whatever may be the value of PZS, that is, at whatever part of its course the star is observed. Hence we infer that the diurnal motion of the stars round the pole is exactly circular.

Theoretical Astronomy.

After having recognised that the celestial bodies move in parallel planes, the next object of the astronomer is to determine whether they revolve with velocities uniform or variable. For this purpose it is necessary to compare, by means of a well-regulated clock, the angular distances between the meridian and the successive positions of a star, with the times elapsed since the star's passage over the meridian. Let *mno* (fig. 4) be the parallel described by a star, and *ss′* two of its successive positions. The arcs *ns*, *ns′*, intercepted between the meridional plane and the planes passing through the axis PP′ and the points *s*, *s′*, are measured by the arcs of the equator C*a*, C*b*. Now, it is the result of constant experience, that the number of degrees in the arc C*a* or C*b* is to the number in the whole circumference as the time employed by the star in describing *na* or *nb* is to the time in which it completes a revolution. The time occupied by the star in completing its revolution is called a sidereal day; and the uniformity of the diurnal revolution enables us to calculate the angle CP*s*, which is measured by C*a*, without having recourse to any other observation than that of the star's meridional passage. Denoting a sidereal day by T, the interval of time which elapses while the star describes the arc *ns* by *t*, and the angle at the pole by P, we shall have the analogy $T : t :: 360 : P$; therefore $P = 370° \frac{t}{T}$; a formula which gives the angle at P, or its measure C*a*. The angles CP*s*, CP*s′*, and *s*P*s′* are called *Hour Angles*, because the arcs which they intercept on the star's parallel of declination correspond to the hours and fractions of an hour into which the sidereal day is divided. For example, if the hour angle *s*P*s′* contain 15°, the two planes passing through *s* and *s′* will intercept on *mn*, the diurnal circle of the star, an arc equal to 15°; consequently there will be 24 such arcs in the whole circumference, each of which will be described in the 24th part of a sidereal day, or in one hour of sidereal time. In consequence of this perfect uniformity of the diurnal motion, the arc which a star describes on its parallel is conveniently measured by the time of its description; and the sidereal day, or the interval between two successive returns of the same star to the plane of the meridian, offers the most perfect *unit of time*, inasmuch as it is exactly the same to all the inhabitants of the earth, and remains absolutely unalterable in all ages, being one of the very few invariable elements of the system of the world.

Fig. 4.

Hour angles.

Method of determining the situations of points on the sphere.

In fixing the position of a point on a plane surface, geometers usually refer it to two straight lines at right angles to each other, the positions of which are supposed to be known. The same practice is imitated by astronomers, who refer the position of any point on the surface of the sphere to two great circles, which are employed as a system of rectangular co-ordinates, and from which all distances are measured. The equator being a circle of the sphere not subject to any arbitrary condition, but determined by the very nature of the spherical revolution, is obviously well adapted for this purpose. It is therefore universally employed as a term of comparison in assigning the places of the celestial bodies. Suppose an hour circle passing through the star *s* to intersect the equator at *a;* the arc *sa*, which measures on the sphere the distance of *s* from the equator, is called the *Declination* of the star. All other stars situated on the same parallel *mo* have the same declination; and it is invariable for all places of the earth, because it is not affected by the diurnal motion which is performed in the parallel *mo*. The declination is *northern* or *southern*, according as the star is situated in the northern or southern hemisphere. It is expressed in degrees from 0 to 90, proceed-

Fig. 4.

Declination.

Theoretical Astronomy.

ing from the equator to the pole. The polar distance Ps is the complement of the declination, because $Ps + sa = 90°$. In order to distinguish s from all other stars which may be situated on the same parallel, we must also know the point a of the equator to which it corresponds; and for this purpose it is necessary to select a point ♈ of the equator for the origin of the co-ordinates. This point ought to be independent of the diurnal motion, otherwise its position could only be determined for a single instant of time; and it must be such that it can be readily found, in whatever part of the earth the observer may be situated. Astronomers have agreed to employ for this purpose the point determined by the intersection of the equator with another very remarkable circle of the sphere, of which we shall speak hereafter, and to count the degrees on the equator, setting out from ♈, from 0 to 360, in the direction opposite to that of the diurnal motion, or from west to east. The arc ♈a, which measures the distance between ♈ and a, is called the *Right Ascension* of the star s: it is also the right ascension of any other star situated in the hour circle PsP'. It is measured by the interval of time which elapses between the transit of the star s over the meridian, and that of the point ♈, which has been chosen as the point of departure. It may be remarked that the point ♈ is also the origin of sidereal time; that is to say, the time is counted 0 hour 0 min. 0 sec. when that point passes the meridian.

Right ascension.

From these definitions it is easy to conceive the general method of forming a catalogue of stars. A clock being regulated to sidereal time, and marking 0 hour at the instant of the transit of the point ♈ (or any star chosen arbitrarily), the hours, minutes, and seconds, are noted at which the stars successively pass the axis of the transit instrument, together with their respective altitudes at the same instant. These observations give the right ascensions and declinations; for the time is easily converted into degrees, at the rate of 15° an hour, or by the formula given above for determining the hour angle. If the star s pass the meridian one hour after s', the arc $a\,b$, which measures the distance between their horary circles, PaP', PbP', is 1 hour or 15°; and the declination of a star s which moves in the parallel kl (fig. 2) is $Æl = H'l - H'Æ$, that is, equal to the difference between its meridional altitude and the complement of the altitude of the pole H P. Modern celestial charts are constructed on the principle of assigning to each star the place indicated by the values of these two co-ordinates; and as observation proves that the mutual distances and relative positions of the stars scarcely undergo any sensible variation, a globe or chart once constructed will serve to represent the state of the heavens for at least a long series of ages.

Fig. 2.

Explanation of the phenomena.

Having now considered the general phenomena of the diurnal revolution, and explained the terms that are technically employed in assigning the positions of the celestial bodies, we may next proceed to inquire how these phenomena are to be accounted for,—whether the stars are really in motion, as they seem to be, or if the apparent motion is only an illusion occasioned by the revolution of our own earth. The perfect uniformity of the motions of the different stars renders it exceedingly improbable that they are disconnected; hence the simplest view of the phenomena is obtained by substituting for each star its projection on the celestial sphere, at an infinite distance, and supposing this sphere, with the projections of all the stars, to revolve in 24 hours from east to west round an immovable axis. But it is easy to see that the phenomena will be equally well explained by supposing that the starry firmament is absolutely at rest, and that the earth revolves in the same time, round the same axis, but in an opposite direction, from west to east. In both cases the stars remain immovable, the phenomena are exactly the same, and, relatively to *Spherical Astronomy*, in which we only concern ourselves with the *apparent* motions, it is absolutely indifferent which of the two hypotheses we adopt. They are both only modes of explaining certain appearances; and the one may be employed which renders the explanation most simple and perspicuous. The proofs of the earth's motion will go on accumulating as we proceed. At present we need only remark, that as the organ of sight makes us acquainted with the existence of relative, and not of absolute motion, it is impossible to decide, merely from appearances, whether the motion we perceive is real or otherwise; for whatever motion one body may have in respect of another, it is always possible to explain the phenomena by supposing it to be perfectly at rest, and the other to move in an opposite direction. The conclusions which we draw from the *optical* effects of motion afford no mathematical certainty with regard to the cause of that motion. The hypothesis of the revolution of the sphere is attended with innumerable and insurmountable difficulties. The distance of the nearest fixed star from the earth is not less than 350,000 times the distance of the sun; a distance which light, prodigious as its velocity is, would not traverse in less than five years. This immense line, therefore, supposing the heavens to revolve round the earth, would form the radius of a circle, the circumference of which, six times larger, would be passed over by the star in the space of 24 hours; its velocity must therefore be $6 \times 5 \times 365 = 10950$ times greater than that of light. This velocity, which is nearly equivalent to 2100 millions of miles in a second of time, is so enormous that it baffles the utmost efforts of the imagination to form any conception of it; and the supposition of its existence will appear still more revolting when we reflect that the distance of the nearest star is probably many thousand times less than that of the Milky Way. If we ascribe the motion to the earth, its velocity, though it may still be supposed great, is moderate in comparison of many well-known phenomena of nature. A point on the equator will describe in 24 hours a circle of about 25,000 miles, or about 17 miles in a minute; a velocity somewhat exceeding that of sound, but 7400 millions of times less rapid than the preceding.

In all that has hitherto been said respecting the apparent motion of the starry sphere, we have only had regard to the innumerable multitude of stars which constantly maintain the same relative situations, and which are in consequence called *Fixed Stars*. There are, however, several other bodies, some of them remarkable on account of their splendour, which, besides participating in the general motion, have peculiar motions of their own, and are incessantly shifting their positions among the fixed stars. An attentive observation of the state of the sky during a few successive evenings, will suffice to show that there are some stars which have in the mean time changed their places; and, on continuing to observe them, they will be found to separate themselves from particular constellations, and gradually but imperceptibly to approach others, till they at length appear, after unequal intervals of time, in an opposite quarter of the heavens. From this circumstance they were designated by the Greeks *Planets*, that is, *wandering stars*, in contradistinction to those which obey only the law of the diurnal motion. Besides the sun and moon, there are five discernible by the naked eye, and which have consequently been known from the remotest ages. These are Mercury, Venus, Mars, Jupiter, and Saturn. Five others, namely, Uranus, Ceres, Pallas, Juno,

and Vesta, have been discovered by the aid of the telescope. Astronomers, with a view to abbreviate their descriptions, have appropriated a certain symbol to each of these planets, as well as to the sun and moon: thus, in the order of distance from the sun, the names and characteristics are as follows:—

The Sun	☉	Ceres	⚳
Mercury	☿	Pallas	⚴
Venus	♀	Jupiter	♃
Mars	♂	Saturn	♄
Vesta	⚶	Uranus	♅
Juno	⚵		

The Earth, which, as we shall afterwards see, is also a planet, and takes its place between Venus and Mars, has for its symbol ⊕, and the moon ☽. Venus, Jupiter, and sometimes Mars, are distinguished by their extraordinary brilliancy. Mercury, on account of his proximity to the sun, is rarely visible to the naked eye. Uranus, discovered by Sir W. Herschel in 1778, can with difficulty, by reason of his great distance, be perceived without a telescope. Ceres, Pallas, Juno, and Vesta, discovered since 1801, are extremely small in size, and can only be seen with the aid of the telescope.

Motions of the sun and moon.

Of all the celestial bodies, the most interesting to us are the sun and moon; and their peculiar motions have accordingly, in every age of astronomy, been studied with the greatest attention. The proper motion of the moon is particularly remarkable. In the course of a single night she separates herself very sensibly from the stars in her vicinity, moving over a space nearly equal to her own breadth in an hour, and completing a whole circuit in about 27 days. The sun moves with much less velocity, but his motion is still sufficiently apparent. If we take notice of the stars which immediately follow him when he sinks under the horizon, we shall find that in the course of a few nights they will be no longer visible. Others which, some time previously, did not set till long after him, have taken their places and now accompany the sun. In the morning similar appearances present themselves, but in a contrary order. The stars which appear in the eastern horizon at sun-rise, are, after a few days, considerably elevated above it at the same time. Thus the sun seems to fall daily behind the stars, by insensible degrees, till at last he appears in the east when they are about to set in the west. To account for these appearances, the ancients supposed the sun's diurnal motion to be really slower than that of the stars; hence they supposed him to be attached to a different sphere. For like reasons they ascribed particular spheres to the moon and each of the planets; and as no trace of these imaginary spheres is perceptible in the heavens, they next supposed them to be crystalline and transparent. The appearances are explained equally well, and with infinitely greater simplicity, by ascribing to the sun a proper motion, in a direction opposite to that of the diurnal rotation of the sphere, in consequence of which he advances to meet the stars, instead of falling behind them.

The greater part of the observations of the early astronomers had for their object the determination of the positions of the stars relatively to the sun at his rising and setting, by which they fixed the seasons, and regulated the operations of agriculture. They distinguished all these phenomena by technical terms, which occur very frequently in the works of the ancient poets, particularly in Hesiod and in Ovid's *Fasti*. A star which rises at the same time with the sun is effaced by his light, and is said to rise *cosmically* (*ortus cosmicus*). Soon after, when the sun by his proper motion has advanced so far to the east that the star can be perceived on the eastern horizon in the morning twilight, it disengages itself from the sun's rays, and is said to rise *heliacally* (*ortus heliacus*). At the end of six months, the sun being diametrically opposite to the same star, it sets as the sun rises, and in this case it is said to set *cosmically* (*occasus cosmicus*): at nearly the same time it rises when the sun sets, and is said to rise *acronically* (*ortus acronyctus*). The sun afterwards begins to approach the star, till he advances so near that it is again about to be effaced by his light; it is now said to set *heliacally*, or just so long after the sun as to be visible when he has disappeared (*occasus heliacus*). At the end of a year, the star again rises and sets at the same moment with the sun; it is now said to set *acronically* (*occasus acronyctus*). These distinctions, and the ancients had several others of the same kind, which are all defined by Ptolemy, are now scarcely ever mentioned. They have lost the whole of their interest since, in the progress of astronomy, more certain methods have been discovered of determining the commencement of the year and the seasons.

Stations and retrogradations.

The proper motions of the planets are in general, like that of the sun, in a direction opposite to the diurnal motion, or from west to east, among the stars: but they do not preserve the same character of uniformity; the planet sometimes becomes stationary among the fixed stars, and even advances from east to west in the direction of the diurnal motion. In this case it is said to *retrograde*. This retrograde motion is, however, not of long continuance. After having been accelerated during a short time, it begins to relax. The planet again becomes *stationary*, and then resumes its *direct* motion from west to east. These phenomena were observed in the remotest antiquity, and their explanation formed the principal part of the rational astronomy of the Greeks and the Arabians.

Comets.

Besides the planets, other bodies occasionally make their appearance in the heavens, which, by reason of the extraordinary phenomena they exhibit, have been frequently contemplated with terror and dismay, and regarded by superstitious ignorance as harbingers of calamity, and precursors of the divine vengeance. These bodies shoot down, from the remote regions of space, with inconceivable velocity, towards the sun. At their first appearance they are small; their light is feeble and dusky; and they are generally accompanied by a sort of nebulosity or luminous tail, from which they have derived their appellation of *Comets* (*coma*, hair). As they approach the sun, their apparent magnitudes and brilliancy greatly increase, and the nebulosity sometimes occupies a large portion of the heavens, presenting a magnificent and astonishing spectacle. Having attained the point of their orbits nearest the sun, they again recede to enormous distances, and vanish by insensible degrees. They differ from the planets not only by the appearances they present, but also by the diversity of their motions; for, instead of being confined to a particular zone, and moving from west to east, they traverse the sky indifferently in all directions. They are visible only in a small part of their orbit, which, being near the sun, is passed over with prodigious rapidity. They seldom continue visible longer than six months. Their number is entirely unknown, but during the last two centuries upwards of 150 have been observed, and their orbits computed.

Thus we recognise three distinct classes of celestial bodies; the planets, the comets, and the fixed stars. It is the business of the astronomer to determine the positions of these bodies in the heavens; to observe their motions, and measure them with precision; to discover the laws by which their courses are regulated; and from these laws to assign the past or future state of the heavens

at any given instant of time. The fixed stars form infinitely the most numerous class; but their motions being sensibly uniform, and their mutual distances invariable, the principal object with regard to them is to determine their places and relative positions. The comets in general return only after long periods; and observations are not yet sufficiently numerous to allow any certain deductions to be made with respect to their nature and constitution. The planets present a great variety of curious phenomena; they are always within our view; observations on them may be multiplied indefinitely; and for this reason, as well as on account of their proximity, and their forming a system of which the earth constitutes a part, they present by far the most interesting objects of astronomical study.

Sect. II.—*Of the Globular Form of the Earth, Parallax, and Refraction.*

Having now considered the general phenomena of the diurnal motion, we proceed next to inquire into the form of the earth, and our situation with respect to the centre round which the celestial sphere appears to revolve. The plane of the horizon seems to be stretched out indefinitely till it actually meets the sky; but this illusion is quickly dissipated by transferring ourselves from one place to another on the surface of the earth, and attending to the phenomena which such a change of place gives rise to. Let an observer, for example, set out from any given point in the northern hemisphere, and proceed directly south. In proportion as he advances, the stars in the southern region of the heavens will be elevated more above the horizon, and describe larger segments of their diurnal circles, while new ones come into view which were invisible at the station he left. On the other hand, the polar star, with those in its vicinity, will be depressed, and some stars which before continued above the horizon during the whole time of their revolution will now rise and set. The planes of the diurnal circles become also more perpendicular to the horizon, so that the aspect of the heavens is entirely changed. If, instead of advancing in the direction of the meridian, the spectator proceeded towards the east or west, he would in this case also remark that his horizon constantly shifted its position. A star will pass his meridian sooner as he advances eastward, or later as he travels westward; in short, by a change of place in any direction whatever, the perpendicular to the horizon, or the plumb-line, will correspond to a different point of the heavens. The plane of the horizon is therefore variable, and its variation by insensible degrees indicates with the greatest evidence the rotundity of the earth. Experience also shows that a spectator sees more of the terrestrial surface in proportion as he is elevated above it; and that on a mountain surrounded by the sea, or standing in the middle of a level plain, the horizon appears equally depressed all round, which is the distinctive feature of a spherical curvature. In fig. 5 let O be the place of a spectator on the summit of a mountain, the straight line H H will represent his horizon, and O*h*, O*h'* the directions of visual rays to the remotest visible points on the surface of the earth. The inclinations of these lines to the plane of the horizon, or the angles HO*h*, H'O*h'* are called the *apparent depression;* and these being always observed to be equal to each other, it follows that the curve *h*A*h'* is a circle. On the Peak of Teneriffe, Humboldt observed the surface of the sea to be depressed on all sides in an angle of nearly 2°. The sun arose to him 12 minutes sooner than to an inhabitant of the plain; and from the plain, the top of the mountain appeared enlightened 12 minutes before the rising or after the setting of the sun. The same phenomena, though on a smaller scale, are observed with regard to every mountain or elevation on the earth. Another familiar illustration of the globular figure of the earth is derived from the successive and gradual disappearance of a ship which leaves the shore and stands out to sea. The hulk disappears before the sails and the rigging, and the top of the mast is the last part that is visible. The ship thus appears gradually to sink under the horizon, exactly in the same manner as she must necessarily do on the supposition that the surface of the sea is spherical. The appearance of the moon at the time she is eclipsed is also demonstrative of the roundness of the earth. When the moon penetrates the shadow of the earth, the line which separates the illuminated from the eclipsed portion of the disk is circular; evidently proving the conical form of the shadow, and consequently the roundness of the body by which the shadow is projected. From all these considerations, it is inferred with the highest certainty that the earth with its waters forms a round mass, isolated in space.

Fig. 5.

The globular form of the earth is a property common to it with the other bodies which compose the planetary system. The sun and moon are evidently round bodies; and when the planets are examined through a telescope their disks appear sensibly circular; and as they are known to have a motion of rotation, in consequence of which they successively present different points of their surfaces to the earth, the uniform roundness of their disks may be taken as a conclusive proof of their sphericity. We shall by and by have occasion to remark other striking analogies between the planets and the earth.

Sensible and rational horizon.

Since the figure of the earth is spherical, the horizontal plane cannot coincide with any considerable portion of its surface. It may be defined to be the plane which touches the earth at any given point, and is perpendicular to the vertical line, or the direction of gravity at that point. The *Sensible Horizon* of any place is the plane which passes through the eye of the spectator, perpendicular to the plumb-line at that place. The *Rational Horizon* is a plane parallel to this, passing through the centre of the earth. The particular phenomena of different places depend on the position of their horizon with respect to the planes of the apparent diurnal motion of the sun and stars. The rational horizon of a place on the equator passes through the poles, and divides equally the equator and its parallels. Hence the days and nights are always equal in such places, and each of the stars performs one half of its revolution above, and the other below its horizon. The circles of diurnal motion are all perpendicular to the horizon, and therefore the inhabitants are said to be under a *Right Sphere.* If a spectator could place himself directly under the pole, his horizon would coincide with the equator, and the whole of the northern celestial hemisphere would be within his view, while no part of the southern hemisphere would be visible to him, on account of its being always beneath the horizon. The circles of the diurnal motion being parallel to the equator, and consequently also to the horizon, the fixed stars would never either rise or set. A spectator thus situated is said to be under a *Parallel Sphere.* In intermediate places the circles of the diurnal motion are oblique to the horizon, one pole being always elevated above it, and the other equally depressed below it. The stars whose distances from the elevated pole are not greater than the arc of its elevation above the horizon never set, while those within the same distance of the depressed pole never rise. These phenomena belong to all places situated between the equator and the poles, and the inhabitants of such places are said to be under an *Oblique Sphere.*

The situation of a place on the surface of the earth is determined by two co-ordinate circles, in the same manner as that of a star on the celestial sphere. Let Z (fig. 2) be a place of which the position is required to be assigned with reference to circles of the terrestrial sphere, analogous to those which we have described as belonging to the sphere of the heavens. Since the axis of the celestial sphere passes through the centre of the earth, we may suppose the poles of the world, the equatorial circle, and the meridians, to be transferred to the earth's surface, so that the same figure may represent either the celestial or terrestrial sphere. The intersection of the plane P Z Æ with the surface of the earth is the terrestrial meridian of the place Z, and the straight lines C Z, C Æ, in that plane, intercept an arc of the terrestrial meridian between Z and the equator, containing as many degrees as the arc of the celestial sphere which measures the declination of the zenith of the place Z. The angle Æ C Z which is measured by the meridional arc Æ Z is called the *Geographical Latitude* of Z. But in order to particularize the point at which the equator is intersected by the meridian, it is necessary to assume some point of the equator to which all the other points of that circle may be referred. The meridian passing through the assumed point is called the *First Meridian;* and the angular distance between the planes of the first and any other meridian measured by the equatorial arc intercepted by these planes on the equator, is called the *Geographical Longitude* of the place through which the last meridian passes. The longitude is said to be *east* or *west*, according as the degrees of the equator are counted from the first meridian towards the east or west. It is usual to reckon the degrees towards the east, all round the globe, or from 0 to 360°. From these definitions it is evident that the geographical latitudes and longitudes are exactly analogous to the declinations and right ascensions on the celestial sphere. The first point of the terrestrial equator cannot be determined by any star or fixed point in the heavens, on account of the diurnal motion; it is therefore necessary to fix its position by means of known places on the earth; and geographers are in the habit of assuming as the first meridian that which passes through the capital city or principal observatory of their country. The choice is of no importance; for in geography, as in astronomy, what is essential to be known is only the *difference* of longitudes or meridians, in order to reduce the situation of a place, or observations which have been made at it, to any indicated meridian.

The length of the terrestrial radius is a very important element in astronomy, inasmuch as it furnishes the observer with the only scale by which he can estimate the distances of the sun, moon, and planets. On the supposition that the figure of the earth is perfectly spherical, the general principles on which its magnitude may be determined are sufficiently obvious; but the accurate determination of its actual dimensions is attended with great practical difficulties, which can only be overcome by the perfect instruments and refined science of modern times. Eratosthenes seems to have been the first who made use of astronomical methods to determine the circumference of the earth, or the length of the meridian. He remarked that, at Syene, in the Thebais, the sun on the meridian, at the time of the summer solstice, was vertical; and that at Alexandria, at the same time, its zenith distance was 7° 12′. Now let S (fig. 6) be the sun, vertical to M, and Z the zenith of Alexandria, C being the centre of the earth, and O Alexandria. The angle Z O S is the sun's zenith distance, which was observed to be 7° 12′. But Z O S = Z C S + O S C; whence, as the angle O S C, which is extremely small on account of the sun's great distance, may be neglected in the calculation, the angle Z C S at the centre is also equal to 7° 12′, and therefore the whole circumference equals $\frac{360°}{7° 12'} \times$ M O. To obtain the length of the meridian, it is therefore only necessary to measure the arc M O. Eratosthenes assumed the distance between Syene and Alexandria to be 5000 stadia; hence the circumference of the earth $= \frac{360°}{7° 12'} \times 5000$ stadia $= 250{,}000$ stadia. The uncertainty which exists respecting the length of the Egyptian stade prevents us from deriving any precise information from this rude attempt to estimate the dimensions of the globe.

The method which has just been described takes for granted that the meridian is exactly circular,—an assumption which, even supposing the method perfect in all other respects, would lead to erroneous results, especially in an arc of so great a magnitude as seven degrees. In a small arc, of 1° for example, the error arising from the non-sphericity of the earth will be insensible; for it is certain, from the phenomena before explained, that the deviation from the spherical figure is not very considerable; and besides, whatever the nature of the meridional curve may be, it will sensibly coincide with its osculating circle, throughout the extent of an arc of 1°. It has been found by numerous and accurate experiments, that the lengths of arcs of 1° on the same meridian are longer in proportion as we advance nearer the pole. Hence, on account of the similarity of the isosceles triangles of which these arcs form the bases, their sides, or the terrestrial radii, must also be longer, and consequently the convexity of the earth is less towards the pole than at the equator. The surface of the earth is extremely irregular, even independently of the inequalities occasioned by mountains and cavities; yet it has been discovered that the meridional curves differ almost insensibly from ellipses; whence it is concluded that the figure of the earth is an ellipsoid of revolution about its shortest axis. In comparing the results of the various measurements which have been made with the formulæ belonging to the dimensions of such a body, this conclusion has been fully verified; and the lengths of the arcs, the ellipticity, the distance of the pole from the equator, and, in short, all the elements of the spheroid, have been determined. The results of theory and observation give an ellipticity amounting very nearly to $\frac{1}{306}$; that is to say, the equatorial is to the polar diameter in the ratio of 306 to 305. The following may be regarded as a very near approximation to the dimensions of the earth in English miles:—

Semidiameter of the equator	3963·7
Semidiameter of the pole	3949·8
Semidiameter at the latitude of 45°	3956·2
Ellipticity $\frac{1}{306}$	13
Length of 1° of the meridian	69·06
Quarter of the meridian of Paris	6214·47

The figure of the earth is one of the most difficult and most important questions of astronomy; and as our limits will not permit us to treat it in this place with all the details which its importance renders necessary, we shall reserve, for a separate article, an account of the different geodetical operations which have been undertaken with a view to determine it, together with the development of the mathematical theory of its equilibrium. See FIGURE OF THE EARTH.

In describing the phenomena of the diurnal revolution, we have supposed the eye of the spectator to be placed

in the centre of motion, on which supposition the apparent and true places of the celestial bodies will be the same. This, however, as is evident, can only be rigorously true in respect of one point of the earth's surface, and is therefore most probably not true of any. Astronomers have on this account agreed to refer all the motions to the centre of the earth; that is, to consider the centre of the earth as the centre of the celestial sphere, and to regard as the true geocentric place of a star, that at which it would appear to a spectator placed at the centre. But the spectator is necessarily placed at the surface. In order, therefore, to render observations made at different stations on the earth's surface comparable with one another, we must consider what changes will be produced in the apparent positions of the celestial bodies, in consequence of their being observed from a point not situated in the centre of motion.

Fig. 6. Parallax.

Let O′ and O (fig. 6) be two stations on the earth's surface on the same meridian, from both of which a star S is observed at the same time. As an object is always seen in the direction of the visual ray, the spectator at O will refer the star S to a certain point I on the surface of the celestial sphere, while the spectator at O′ will refer it to a different point I′ in the direction O′ I′; and the difference of the apparent places I and I′ depends on the magnitude of the angle OSO′, which is subtended by the chord of the arc OO′. If a third spectator could be placed at C, the centre of the earth, the same star would appear to him in the direction CS, and be referred to its true place on the sphere at Q. Now, the difference between the angles ZOS and ZCS, that is, the angle OSC, under which the radius of the earth is seen by an observer at S, is called the *parallax* of S. On account of the great distance of the fixed stars, this angle is altogether insensible with regard to them; it is, however, very sensible in the case of the moon, with regard to which it amounts to about 1°. The greatest parallax of the nearest planets does not exceed 30″.

From the definition which has just been given, it appears that the parallax of a star is the angle comprised between two lines drawn from the star, the one to the centre of the earth, and the other to any point whatever on its surface. But it is evident, that while the distance of S from the earth remains constant, the angle OSC will vary with the angle ZOS, that is, with the distance of the star from the zenith, or its altitude above the horizon.

Fig. 7.

Let OH (fig. 7) represent the horizon. It is easy to see that the angle OSC will have its greatest value when OS touches the surface of the earth, or coincides with the horizon OH, that is, when the angle ZOS = 90°. It is equally evident that the parallax OSC vanishes entirely when the line CS coincides with CZ, that is, when the star is in the zenith of the observer at O; hence the parallax depends on the altitude of the star, according to a law which we now proceed to determine.

Fig. 7.

In the triangle OSC (fig. 7), we have sin. OSC : sin. SOZ :: CO : CS, whence sin. OSC $= \frac{\text{CO}}{\text{CS}}$ sin. SOZ. Let the angle SOZ, or the zenith distance of the star = Z, the semidiameter of the earth OC = a, the distance of the star CS = r, and the parallax OSC = p, we have then sin. $p = \frac{a}{r}$ sin. Z. On account of the smallness of the angle p, which, as we have mentioned, in no case exceeds 1°, the arc may be substituted for the sine (for their difference even in an arc of 1° does not exceed 0″·18): the above expression therefore becomes $p = \frac{a}{r}$ sin. Z; that is to say, the parallax of a star is proportional to the sine of its zenith distance. At the zenith, Z = 0, therefore sin. Z = 0, and the parallax vanishes: at the horizon, Z = 90°, and sin. Z = 1; the parallax, therefore, becomes equal to $\frac{a}{r}$. In this case it is at its maximum, and is denominated the *Horizontal Parallax;* in all other cases it is called the *Parallax of Altitude.* Denoting the horizontal parallax by P, we have P $= \frac{a}{r}$, whence

$$p = \text{P sin. Z};$$

that is to say, *the parallax of altitude is equal to the horizontal parallax, multiplied by the sine of the apparent zenith distance.* It is evident that the apparent altitude SOH is always less than the true altitude SBH, by the whole amount of the parallax; the effect of the parallax is therefore to depress the object, or increase its zenith distance; hence, if θ be the apparent altitude of the star, and θ' its true altitude, θ' will be found from the equation $\theta' = \theta + \text{P}$ sin. Z.

From the above results it is manifest, that if the horizontal parallax can be by any means determined, the parallax at any other altitude will be found at the same time. The determination of the horizontal parallax is, however, attended with considerable difficulty, and various methods have been proposed and practised to ascertain its exact amount, modified by particular circumstances in the cases of the different celestial bodies. The method, however, which serves as the basis of all the others is extremely simple, and exactly analogous to that by which the distance of a remote object is determined on the surface of the earth. Suppose two observers to be stationed at the points O and O′ (fig. 6), of which the latitudes are known, and which are both situated on the same meridian, and let them simultaneously observe the zenith distances of the star S; these observations will give the angles ZOS, Z′O′S, whence their supplements SOC and SO′C become known at the same time. A third angle of the quadrilateral figure SOCO′, namely OCO′, is also known, being measured by the meridional arc OMO′, the difference or sum of the latitudes of the two observers, according as they are on the same or opposite sides of the equator. The two sides also, CO and CO′, being semidiameters of the earth, are supposed to be known; every part of the quadrilateral figure is therefore determined, and its diagonal CS may be calculated by the rules of plane trigonometry. But when CS is determined, the horizontal parallax is obtained immediately from the formula P $= \frac{a}{r}$, that is, P $= \frac{\text{CO}}{\text{CS}}$. On this principle the horizontal parallax of the moon was determined by Lacaille and Lalande, the former observing at the Cape of Good Hope, and the latter at Berlin; and the parallax of Mars by Lacaille at the Cape, and Wargentin at Stockholm. Fig. 6.

Let us suppose two lines to be drawn from the centre of a planet touching the surface of the earth in points diametrically opposite; the inclination of these two straight lines is the double of the horizontal parallax; but the same angle also measures the diameter of the earth as seen from the planet: hence the horizontal parallax of a planet is equal to the apparent semidiameter of the earth at the distance of the planet. From this consideration the true diameter, and consequently the volume, of a planet may be found by measuring its apparent diameter, that is, the optical angle under which its diameter appears when seen from the earth. Let d be the apparent, and D the true diameter of a planet; the angle $\frac{1}{2}d$ is comprised between two straight lines drawn from the

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earth, the first of which is directed to the centre of the planet, and the last is a tangent to it: hence $\frac{1}{2}$ D $= r$ tan. $\frac{1}{2}d$ or r sin. $\frac{1}{2}d$, according as r is the line which touches the planet or that which is directed to its centre. Now, on account of the smallness of the angle $\frac{1}{2}d$, the sine and tangent are sensibly equal to the arc; we may therefore suppose in all cases $D = r\,d$. Combining this with the equation $P = \frac{a}{r}$, we deduce $\frac{D}{a} = \frac{d}{P}$; which gives the ratio between the true diameters of the planet and the earth in terms of the apparent magnitude and horizontal parallax of the planet. It follows also from this last equation that $\frac{d}{P}$, or the ratio of the apparent diameter and parallax of a planet, is constant; the horizontal parallax may therefore be found at any time whatever by measuring the planet's diameter.

From the equation $P = \frac{a}{r}$, we have $r = \frac{a}{P}$; that is, the distance of a planet from the earth is known in terms of its parallax and the earth's semidiameter. The parallaxes, therefore, give the ratio of the distances of all the planets from the earth, and consequently of their distances from one another, and from the sun; hence the radius of the earth furnishes the scale by which the astronomer measures the dimensions of the whole solar system, and the magnitudes or volumes of all the bodies of which it is composed. On this account the accurate determination of the parallaxes of the celestial bodies is a problem of great importance in practical astronomy.

Fig. 7. It is evident from the mere inspection of the figure, that the plane in which the straight lines C S and O S are situated is the vertical plane passing through S, consequently the whole effect of the parallax is to diminish the altitude of a planet in its vertical circle. When the observation, therefore, is made in the meridian, the effect of the parallax is to alter the declination, without producing any change whatever in the right ascension of the planet. Out of the meridian it is necessary to have regard to the azimuth or hour angle, as well as to the altitude, in calculating the correction due to the parallax. When we suppose the earth to be spherical, the formulæ for the calculation of the parallax are extremely simple, because the radius is constant, and the vertical line, or perpendicular to the surface of the earth, passes through its centre. But in the case of the true or elliptical figure of the earth neither of these circumstances takes place. The radius in this case is variable, and must be determined by a particular process of computation for every point on the meridian; and the vertical line, with reference to which the latitude of the place and the altitudes are determined, does not pass through the centre of the earth, but makes different angles with the axis. These circumstances render the calculation of the parallax a matter of much greater complication and difficulty.

The term parallax in its general signification properly denotes *change* of place. There are consequently various kinds of parallaxes, such as parallax of right ascension, of declination, longitude, latitude, &c. In what has preceded, we have supposed the earth to be at rest in the centre of the universe, and therefore have had regard solely to the variations produced in the apparent diurnal motions by the eccentric position of the observer on the surface of the earth, and which are comprehended generally under the denomination of the *diurnal* parallax.

The effects of the diurnal parallax are only sensible with regard to those bodies of which the distance from the earth is not so great as to be incomparable with the earth's semidiameter. That the apparent place of an object must be changed in consequence of a change in the situation of the observer, is a simple geometrical truth which no experiment was required to discover. The first observers must accordingly have anticipated a parallax in all the celestial bodies; and it was doubtless only after considerable experience that they admitted the existence of any exception to the general law. There is, however, another cause of variation in the apparent positions of the celestial bodies also connected with the earth, the existence of which could not be known *a priori*, but must have been discovered by experience alone. We allude to the refraction of the rays of light in passing through the earth's atmosphere.

Refraction.

The angular distance between two stars is found to undergo very sensible variations at different hours of the day. This phenomenon cannot be explained by any proper motion of the stars, because it evidently depends on their altitude above the horizon; and the differences are found to be the same daily at the same altitude. It is most striking when we compare a star which, without setting, passes the meridian twice a day, once near the zenith, and the second time near the horizon, with another star situated very near the pole, and of which the altitude is consequently nearly invariable. It will be found that at the time of the first transit the distance between the two stars is greater than at the second by nearly half a degree. It is evident, therefore, that the phenomenon consists in diminishing the distance between a star situated in the horizon and the visible pole, that is to say, in elevating the stars, whereas the effect of the parallax is to depress them. The refraction also takes place in an equal degree with regard to the fixed stars, and even the moon and planets, without being in any degree modified by the great differences in the distances of the celestial bodies, contrary in this respect likewise to the parallax, which depends entirely on the distance. The reason of this will be evident from the consideration of the physical cause of the phenomenon.

Theory of refraction.

According to the known principles of optics, a ray of light, in passing obliquely from one transparent medium into another of a different density, does not hold on in its rectilinear course, but is refracted, or bent towards the denser medium. Now, the atmosphere which surrounds the earth may be regarded as composed of an infinity of concentric spherical strata, the densities of which are greater in proportion as they are nearer to the earth's surface. When a ray of light, therefore, proceeding from a star enters the atmosphere, it is inflected towards the earth, or bent so as to form a smaller angle with a perpendicular to the surface of the earth; and this inflection will be increased by every successive stratum of the atmosphere through which the light passes. In fig. 8, let Fig. 8. AA′, BB′, CC′, represent the boundaries of the successive strata, which, for the sake of illustration, we here suppose to have a finite thickness. A ray of light proceeding from S comes in contact with the highest stratum of the atmosphere AA′ at a. The molecular attraction of this atmospherical stratum, acting in the direction of a normal to A A′ at a, causes the luminous ray to deviate from the direction S x, and assume another, $a\,y$, in which it would continue to move if the atmosphere were equally dense from A A′ to the earth. But in the course of its progress the ray penetrates another denser stratum at b, and consequently suffers another inflection; so that instead of proceeding in the direction $a\,y$, it is bent into a new direction bz, more nearly perpendicular to the concentric strata. A similar effect is produced at c, so that the luminous ray, when it finally reaches the observer at O, has as-

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sumed the direction c O. In its progress from a to O, it has therefore successively moved in the direction of the sides of the polygon a, b, c, O; and to the spectator at O, the star from which it proceeded, instead of appearing in its true place at S, will appear to be at S′, or in the last direction of the visual ray. Now, if A A′ is the most elevated stratum of the atmosphere into which the ray enters in the direction S a, it is clear that the whole effect is produced by the atmospherical strata situated below A A′, and that the length of S a is perfectly indifferent; hence the refraction is entirely independent of the distance of the stars, provided they are beyond the limits of the earth's atmosphere.

The decrease of the density of the atmosphere, from the surface of the earth upwards, follows the law of continuity, or takes place by insensible degrees; so that the luminous ray, in traversing the atmosphere, enters at every instant into a denser medium, and is therefore continually brought nearer and nearer to the vertical direction. Hence the true path of the ray is curvilinear, and concave towards the earth, as represented in fig. 9. This is equivalent to the supposition that the thickness of the different concentric strata of uniform density is infinitely small, and that the light, as it successively penetrates each, deviates from its former path by an infinitely small angle, which may be considered as the differential of the refraction, the total amount of which will therefore be obtained by integration. The direction of the ray, when it reaches the eye of the observer, is the tangent to the last portion of its curvilinear path; and the apparent zenith distance of the star will be ZOS′, while the real zenith distance is ZOS. The difference of these two angles, namely S′OS, is what is denominated the *Astronomical Refraction*. It is evident that the whole path of the ray is confined to the vertical plane, in which the star and the eye of the observer are situated; for the earth and its atmosphere being very nearly spherical, that plane will divide the strata symmetrically; the attracting forces will therefore be equal on each side of it, and consequently produce no effect in a lateral direction. When the observed star is due north or south, the vertical plane is the plane of the meridian; hence, in meridional observations, the whole of the refraction, like that of the parallax, takes place in declination, while the right ascension remains unaltered.

Fig. 9.

Law of refraction.

It is evident that the amount of the refraction is greater in proportion as the observed star is nearer to the horizon; for in this case the luminous rays strike the tangent planes of the atmospherical strata more obliquely, and have besides to traverse a greater extent of atmosphere before they arrive at the eye of the observer. On determining by experiment the refraction at every altitude from zero to 90°, tables of *Refraction* may be constructed, which will furnish the means of discovering the law of its diminution; but as such a process would be exceedingly tedious, and likewise subject to lead to erroneous results on account of the inevitable errors of observation, it is found more convenient to assume some hypothesis for a basis of calculation, and to verify the results which it leads to by comparing them with observation. In regard to media which may be said to be permanent, such, for instance, as water and glass, the determination of the refraction is not attended with great difficulty; but the circumstances are greatly altered when we come to make experiments on the atmosphere. In this case the difficulty arises from the incessant changes which the atmosphere is undergoing relatively to its refringent powers; changes which it is impossible for the observer fully to appreciate, inasmuch as he can only determine its physical state within a short distance of the earth, while that of the upper strata remains wholly unknown to him. The refringent power of the atmosphere is affected by its density and temperature. The effects of the humidity are insensible; for the most accurate experiments seem to prove that the watery vapours diminish the density of the air in the same ratio as their refractive power is greater. It is therefore only necessary, even in delicate experiments, to have regard to the state of the barometer and thermometer at the time the observation is made. At a medium density, and at the temperature of melting ice, it was found by Biot and Arago, from a great number of exact experiments, that at any altitude between 10° and the zenith the refraction is very nearly represented by the formula $r = 60''\cdot6 \tan. (Z - 3\cdot25 \times r)$, in which r is the refraction corresponding to a given zenith distance Z. With the exception of the numerical co-efficients, this formula was first given by Bradley; but whether it was deduced from theory by that great astronomer, or was only empirical, is uncertain. Bradley's formula was $r = 57''$ tan. $(Z - 3 \times r)$. When the direction of the luminous rays makes a smaller angle than 10° with the horizon, it becomes indispensable to take into account, in the calculation of the refraction, the law of the variation of the density of the atmosphere at different altitudes; a law which is subject to incessant variation, from the operation of winds, and other causes which agitate the atmosphere, as well as the decrease of temperature in the superior regions. For this reason all astronomical observations which have not refraction directly for their object, or which are by their nature independent of its influence, are made at an elevation exceeding 10°. For lower altitudes, it is to be feared that no theory will ever be found sufficiently exact to entitle the observations to much confidence.

First observation of refraction.

The existence of the atmospherical refraction was not unknown to the ancient astronomers; but it is only in modern times that the subject has been studied with the requisite care to admit of its influence being calculated in the reduction of observations. Ptolemy does not allude to the subject in the *Almagest*, but he has given a sufficiently exact idea of it in his work on *Optics*. He mentions experiments made to ascertain how far a ray of light is bent from its rectilinear course in passing from air into glass and water; and observes that the astronomical refraction brings a star nearer to the zenith, and that it is feebler in proportion as the star is more elevated. He likewise indicates a method of measuring its effects, although he does not seem to have attempted to practise it. The same notions, but in a less precise form, were reproduced in the *Optics* of Alhazen. Walther began to estimate the effects of refraction near the horizon; and Tycho, a century after, found the means of measuring them with greater accuracy, and was thereby enabled to construct a table. Tycho estimated the horizontal refraction at 34′, and supposed it to vanish at the altitude of 45°; which proves that his ideas on the subject were less accurate than those of Ptolemy, who says expressly that it vanished only at the zenith. Dominic Cassini was the first who proposed an hypothesis for calculating the refraction at any altitude; and he computed a table, which was published in 1662. Since that time the subject of refraction has been investigated, theoretically and practically, with the most scrupulous and delicate attention, and tables constructed to exhibit its amount at every altitude, and at the different seasons of the year. (See *Mécanique Céleste*, tom. iv. p. 231; Mr Ivory's Paper in the *Phil. Trans.* for 1823, p. 409; Delambre, *Astronomie du xviii. Siècle*, p. 774.)

The refringent power of the atmosphere gives rise to a number of curious phenomena. When the sun appears in

Oval appearance of the sun and moon in the horizon.

the horizon, the rays of light which issue from the extremities of his vertical diameter are refracted unequally on account of the difference of altitude, so that the disk, at other times circular, then assumes an oval appearance; and on measuring the horizontal and vertical diameters by means of the micrometer, the former is sometimes found to exceed the latter by four or five minutes of a degree. This effect is particularly remarkable when the sun is observed at his rising or setting from the top of a mountain, or an elevation near the sea-shore, in which cases the difference of the two diameters sometimes, in particular states of the atmosphere, amounts to upwards of 6′, or a fifth of the whole apparent diameter of the sun. In the case of the moon this oval appearance is seldom so perceptible; for unless she happens to be exactly full, or in opposition, at the same time that she is in the horizon—and this can rarely be the case—the defect of the illumination of her disk reduces her figure to those rounder but somewhat irregular shapes which it often exhibits. The horizontal refraction being equal to the apparent diameter of the sun or moon, it happens also that either of these luminaries, and consequently any other of the celestial bodies, may be entirely visible above the plane of the horizon, when in fact it has set below it. A curious instance of this was observed at Paris in 1750. The moon rose eclipsed, while the sun, whose place at the time of a lunar eclipse is diametrically opposite to that of the moon, still appeared above the horizon. Another phenomenon occasioned by the refraction of the atmosphere is the appearance of the moon when she is eclipsed, or immersed in the earth's shadow, and consequently receives no light directly from the sun. On these occasions her disk continues distinctly visible, and is of a dusky red colour, exhibiting the appearance of tarnished copper, or iron nearly red-hot. This phenomenon occasioned great perplexity to the ancient astronomers who were unacquainted with the refractive powers of the atmosphere; and some of them ascribed it to the native light of the moon, in virtue of which she continues visible when hid from the sun's rays. Plutarch ingeniously supposed it to be occasioned by the light of the stars reflected from the dark surface of the moon; but the quantity of this light is greatly too small to produce the effect in question. It is now explained by the scattered beams of light bent into the earth's shadow by refraction in their passage through the atmosphere.

Twilight.

The refraction of the rays of light in traversing the earth's atmosphere is the cause of *Twilight*, which sensibly lengthens the duration of the day, and prevents a sudden transition from light to darkness on the disappearance of the sun. When the sun is more than 33′ below the horizon, the refraction is not powerful enough to bring his rays sufficiently near the earth to reach our eyes; they pass over our heads, and are irregularly reflected by the molecules of the atmosphere. By this means a portion of the celestial vault is enlightened, while the sun is invisible. This illumination of the upper regions is called the twilight. It commences as soon as objects can be distinguished before sun-rise, and terminates when they cease to be visible after the sun has set. The time, however, at which the twilight commences and terminates cannot be assigned with any degree of precision. It is generally supposed to be limited by the depression of the sun 18° below the horizon. Lacaille found the limit in the torrid zone to be between 16° and 17°. According to Lemonnier, it varies in France between 17° and 21°. The duration of the twilight will evidently be longer or shorter according as the inclination of the plane of the sun's orbit to the horizon is more or less oblique.

To assign the time at which it is a maximum or minimum, or of a given length at a given latitude, is a problem of pure geometry, which has been frequently solved since the time of the Bernoullis.

Scintillation of the stars.

The scintillation or twinkling of the stars is another phenomenon produced by certain modifications of atmospherical refraction. The atmosphere is at all times more or less agitated; and on this account the clusters of molecules of which it is composed are constantly undergoing momentary compressions and dilatations, which occasion minute differences of refraction, and consequent changes in the directions of the luminous rays. The minute and rapid variations thus occasioned in the apparent places of the stars produce the twinkling or tremulous appearances which, in certain states of the atmosphere, particularly on the approach of rain after a long drought, are very remarkable. The agitations of the atmosphere are manifest to the eye in the tremulous motion of the shadows cast from high towers, and in looking at objects through the smoke of a chimney, or over beds of hot sand. The scintillation of the planets is much less than that of the stars. This proceeds from the magnitude of their disks, which, although apparently very small, are still far greater than those of the fixed stars, and indeed so considerable, that the accidental variations in the directions of the rays of light are too minute to displace them entirely. The borders of their disks are affected only by a slight undulation; whereas the stars, which are merely brilliant points of insensible magnitude, undergo a total displacement.

Horizontal moon.

The apparent enlargement of the sun and moon in the horizon is an optical illusion, connected in some measure with the atmosphere, of which various explanations have been given since the time of Ptolemy. According to the ordinary laws of vision, the celestial bodies, particularly the moon, which is nearest to the earth, ought to appear largest in the meridian, because their distance is then less than when they are near the horizon; and yet daily experience proves that the contrary takes place. To an observer placed at E (fig. 10), the visual angle subtended by the moon in the horizon at M is somewhat less than that under which she appears in the zenith at O; and this fact, a consequence indeed of her circular motion, is proved by accurate measurements of her diameters in those circumstances by the micrometer. The mean apparent diameter of the moon, at her greatest height, is 31′ in round numbers, but in the horizon she seems to the eye two or three times larger. The commonly received explanation of this phenomenon was first given by Descartes, and after him by Dr Wallis, James Gregory, Malebranche, Huygens, and others, and may be stated as follows. The opinion which we form of the magnitude of a distant body does not depend exclusively on the visual angle under which it appears, but also on its distance; and we judge of the distance by a comparison with other bodies. When the moon is near the zenith there is no interposing object with which we can compare her, the matter of the atmosphere being scarcely visible. Deceived by the absence of intermediate objects, we suppose her to be very near. On the other hand, we are used to observe a large extent of land lying between us and objects near the horizon, at the extremity of which the sky begins to appear; we therefore suppose the sky, with all the objects which are visible in it, to be at a great distance. The illusion is also greatly aided by the comparative feebleness of the light of the moon in the horizon, which renders us in a manner sensible of the interposition of the atmosphere. Hence the moon, though seen under nearly the same angle, alternately appears very large and very small. Desaguliers illustrated the doctrine of the horizontal moon on the

Fig. 10.

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supposition of our imagining the visible heavens to be only a small portion of a spherical surface, as *mnop* (fig. 10), in which case the moon, at different altitudes, will appear to be at different distances, and therefore seem to vary in magnitude, as at *m*, *n*, *o*. It is evident, however, that this affords no explanation of the phenomenon; for why does the sky, it may be asked, appear to be a smaller segment than a hemisphere? In the solution of this question the whole difficulty is contained.

Fig. 10.

It may be remarked that these illusions disappear as soon as the intermediate objects are concealed from view. They may be destroyed by regarding the moon through a tube, which permits her disk alone to be seen, and in this manner she will appear no larger at the horizon than near the zenith. The same effect may be produced by viewing her through a smoked glass, because the dark tint permits only the luminous object to be seen, and conceals all the rest. The only precaution necessary to be observed in making this experiment, is to place the eye in such a position that the surrounding bodies may not be visible.

CHAP. II.

OF THE SUN.

SECT. I.—*Of the Apparent Circular Motion of the Sun in the Ecliptic, and Position of the Ecliptic in Space.*

The consideration of the diurnal motion common to all the celestial bodies, and the succession of day and night resulting from it, forms the first object of astronomy. The second is to pass from the diurnal motion of the sphere to the proper motion of the sun, and from the vicissitudes of the day to the seasons of the year. The sun, as has already been remarked, is constantly shifting his place among the stars. If we observe the altitude of any star, or group of stars, above the eastern horizon at sun-set, we shall find, on making the same observation a few days afterwards, that its elevation is considerably increased, and that it has approached nearer to the meridian. At the end of three months it will appear at sun-set on the meridian, and from that time continue to advance nearer and nearer to the sun, till it is at last concealed by the splendour of his rays. After remaining for some time invisible, it will again make its appearance in the morning to the westward of the sun, and its distance from him will continue to increase daily, till, at the end of a year, it has made a complete circuit of the sky, and regained the position it occupied at the time of the first observation. The earliest observers explained this phenomenon by supposing the diurnal motion of the sun to be less rapid than that of the stars, in consequence of which he constantly falls behind them. This supposition would be admissible if the sun remained constantly in the plane of the equator; but as he deviates considerably from that plane, on both sides of it, it is infinitely more simple to ascribe to the sun a motion of his own, independent of the diurnal motion, and performed in a contrary direction, in virtue of which he traces an oblique route among the stars.

Sun's course in the heavens.

The oblique path of the sun may be determined by observing the positions of the stars near which he successively passes in the course of the year. The same object is however accomplished with much greater precision by the modern practice of observing his declinations and right ascensions, that is to say, his distances from the equator, and an arbitrary meridian. In this manner his place may be accurately assigned every day; and, by a repetition of similar observations, a series of points will be obtained on the surface of the celestial sphere, which mark out his annual course. The result of constant experience shows, that the declination reaches its maximum on the south side of the equator about the 22d of December, when it amounts to 23·465 degrees. From this time it gradually diminishes till about the 21st of March, when the sun reaches the plane of the equator. At this time the days and nights are of equal length all over the earth, and the instant of time at which the sun's centre is in the equatorial plane is called the instant of the equinox. The sun then appears on the opposite side of the equator, and his declination or meridional altitude continues to increase till about the 22d of June, when he becomes stationary, and then again shapes his course towards the equator. His maximum declination on the north side of the equator is exactly equal to that on the south, amounting to 23°·465. The sun now continues to approach the equator till about the 24th of September, when he again reaches that plane, and a second equinox succeeds. Continuing still to move in the same direction, he declines from the equator southward, till he reaches his former limit about the 22d of December, after which he resumes his former course.

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Tropics.

The two small circles of the sphere, parallel to the equator, which pass through the two points where the declination is great, are called the *Solstices*, or the *Tropics*; that on the northern hemisphere is called the *Tropic of Cancer*, and the other is called the *Tropic of Capricorn*. These two parallels, which mark the extreme limits of the sun's declination, are, as has just been stated, equally distant from the equator, with regard to which the variations of declination on either side are perfectly symmetrical and uniform.

If at the time of the vernal equinox we remark the stars which set in the true west while the sun is rising in the east, and which are then separated from him by a semicircumference, it will be found that the difference of their right ascensions, and the right ascensions of those which have precisely a similar situation relatively to the sun at the time of the autumnal equinox, is exactly 180°. It follows, therefore, that the solar orbit intersects the equator in two points diametrically opposite; but we have seen that its northern and southern declinations are equal; hence the orbit projected on the sphere must be a great circle, provided it lies wholly in the same plane. Whether this is the case or not it will be easy to prove by means of a few observations, in the following manner.

Fig. 11.

Let AQ (fig. 11) be the equator, AE the orbit of the sun, PSM, PTN two circles of declination, drawn through any two points S and T of the orbit. If the sun's path is confined to a plane, then AE must be a great circle, and we shall have the equation $\sin. AM = \frac{\tan. MS}{\tan. MAS}$, according to the well-known properties of spherical triangles. Let the cotangent of the unknown but constant angle $MAS = n$, the declinations $MS = D$, $NT = D'$, the right ascensions $AM = Æ$, $AN = Æ'$; then, according to the above formula, we must have $\sin. Æ = n \tan. D$, and $\sin. Æ' = n \tan. D'$, at whatever points of the orbit S and T may be situated. From these two last equations there result also $\cos. Æ = \sqrt{1 - n^2 \tan.^2 D}$, $\cos. Æ' = \sqrt{1 - n^2 \tan.^2 D'}$, which, being substituted in the trigonometrical formula $\sin. (Æ' - Æ) = \sin. Æ' \cos. Æ - \cos. Æ' \sin. Æ$, we shall have $\sin. (Æ' - Æ) = n \tan. D' \sqrt{1 - n^2 \tan.^2 D} - n \tan. D \sqrt{1 - n^2 \tan.^2 D'}$. The observations of the meridional altitudes will give the declinations D and D'; and the difference of right ascensions, $Æ' - Æ$, will be found by comparing the time of the sun's culmination, or transit over

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the meridian, with that of a star. If, therefore, it is found that, by assigning a certain constant value to n, this equation will satisfy all the observations, combined by pairs, of the sun's right ascensions and declinations, it will follow that the plane determined by any two points in the sun's course and the point in which it intersects the equator, has always the same inclination to the equator; in other words, all the planes so determined are identical.

Now the observations of the sun's right ascensions and meridional altitudes, which have been made daily during so great a number of years, and under so many different meridians, are found to conform entirely with the preceding formulæ: they therefore furnish so many proofs that the projection of the sun's orbit is a great circle of the celestial sphere, and that the orbit itself is wholly confined to the same plane.

Ecliptic.

The great circle which the sun describes in virtue of his proper motion is called the *Ecliptic*. It has received this name from the circumstance that the moon, during eclipses, is either in the same plane or very near it. These phenomena can in fact only happen when the sun, earth, and moon are nearly in the same straight line, and, consequently, when the moon is in the same plane with the earth and the sun. The angle formed by the planes of the ecliptic and equator, and which is measured by the arc of a circle of declination intercepted between the equator and tropic, is called the *Obliquity of the Ecliptic*. The two points in which the equator and ecliptic intersect each other are called the *Equinoctial Points*: they are also denominated the *Nodes of the Equator*; and the straight line conceived to join them is the *Line of the Equinoxes*, or the *Line of the Nodes*. The node through which the sun passes on coming from the south to the north of the equator is called the *Ascending Node*, and is usually distinguished by the character ☊; the opposite node is the *Descending Node*, and is marked by ☋. A straight line passing through the centre of the earth, perpendicular to the plane of the ecliptic, is called the *Axis*, and the points in which its prolongation meets the sphere are called the *Poles, of the Ecliptic*; these denominations being analogous to those of the axis and poles of the equator. The two small circles of the sphere which pass through the poles of the ecliptic, and are parallel to the equator, are called the *Polar Circles*.

Nodes.

Signs of the Zodiac.

The ecliptic has been divided by astronomers, from time immemorial, into twelve equal parts, called *Signs*, each of which consequently contains 30 degrees. The names and symbols by which they are characterized are as follows:—

North of the Equator.		South of the Equator.	
Aries	♈	Libra	♎
Taurus	♉	Scorpio	♏
Gemini	♊	Sagittarius	♐
Cancer	♋	Capricornus	♑
Leo	♌	Aquarius	♒
Virgo	♍	Pisces	♓

In each of these signs the ancients formed groups of stars, which they denominated *asterisms*, *constellations*, *animals* (ζῶδια), not confined to the ecliptic, but included within an imaginary belt, extending 8° on each side of it, to which they gave the name of *Zodiac* (ζῳδιακος κυκλος, *circle* or *zone of the animals*). The term *sign* is now employed only to denote an arc of 30°, and will probably soon be banished entirely from the astronomical tables. It is already confined to the tables of the planets. Thus, to denote that the longitude of a planet is 276° 12′, it is usual to write 9ˢ 6° 12′. Formerly it was usual to employ the characteristic symbol, and to write ♑ 6° 12′, meaning that the planet was 12′ in the 6th degree of Capricornus, or the tenth sign. This inconvenient practice is now laid aside, and the signs, when they are employed, are simply distinguished by the ordinal numbers.

As the greater part of the celestial phenomena connected with the planetary system take place either in the ecliptic or in planes not greatly inclined to it, it is found to be most convenient to refer the positions of the planets, and frequently those of the stars also, to that plane. The first point of Aries, which is the technical expression for the intersection of the ecliptic and equator, or the place of the sun at the vernal equinox, is assumed as the origin from which the degrees of the equator, as well as of the ecliptic, are counted from west to east, or in the direction of the sun's annual motion. The angular distance of the sun from this point is called his *Longitude*; and the longitude of a star is the arc intercepted on the ecliptic between the same point and a great circle passing through the star perpendicular to the ecliptic. The arc of this circle intercepted between the star and the ecliptic, or, which is the same thing, the complement of the star's distance from the pole of the ecliptic, is called the *Latitude* of the star; so that longitude and latitude are with regard to the ecliptic what right ascension and declination are with regard to the equator. Thus, let O♈Q (fig. 12) be the equator, I♈L the ecliptic, P and E the north poles of these two circles respectively, and S the place of a star. Having drawn through the pole of the ecliptic and the star the great circle ESM perpendicular to the ecliptic in M, then ♈M is the longitude of S, counted on the ecliptic from the vernal point ♈ towards the east; and SM, the distance of the star from the ecliptic, is its latitude; and for this reason all great circles passing through the poles of the ecliptic are called *Circles of Latitude*. The place of a star is thus determined by its longitude ♈M, and its latitude SM, as well as by its right ascension ♈R, and its declination SR; and when the angle L♈Q is known, it is easy to pass from the one system of co-ordinates to the other by means of the formulæ of spherical trigonometry. These formulæ are of constant use, for it is the declinations and right ascensions only which are directly observed. Fig. 12.

Obliquity of the ecliptic.

The plane of the sun's orbit will be determined completely when its inclination to the equator and the position of the line of the nodes in space have been made known by observation. The declination of the sun twice a year, namely, at the summer and winter solstice, is equal to the obliquity of the ecliptic; whence, if the solstice happened exactly at mid-day, the obliquity would be given directly by an observation of his meridional altitude. This circumstance, however, can happen only for one terrestrial meridian; but as the declination of the sun when he approaches the tropics varies little from one day to another, his greatest observed declination will be a very near approximation to the obliquity, at whatever part of the earth the observation may have been made. It is easy, however, to correct the error which results from the observation being made on a meridian different from the solstitial colure. Taking an example from Woodhouse, let us suppose the sun's declination to be observed on three successive days (the 20th, 21st, and 22d of June), and found to be on these days respectively,

$$23° \; 27' \; 37'', \quad 23° \; 27' \; 41'', \quad 23° \; 27' \; 20'';$$

then it is obvious, that if the middle observation gave the greatest inclination exactly, the other two would differ from it equally, which they do not. The maximum declination is therefore a quantity somewhat different from 23° 27′ 41″; and it is easy to conclude, from the inspection of the numbers, that it is nearer to 23° 27′ 41″ than to either of the other two. It is obvious, therefore, that that observation must have been made within 12 hours of the

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time when the sun was exactly in the solstitial point. In order to form an exact notion of the amount of error which may possibly arise from this circumstance, let S (fig. 13) be the place of the sun at the time of the observation, and X the true but as yet unknown solstitial point, and S s, X x meridional arcs intersecting the equator in s and x. The arc S X must be less than 30′, for in 12 hours the variation of the sun's longitude does not exceed an arc of that magnitude. Suppose it 30′: then, by Napier's rules,

Pl. LXXX. Fig. 13.

$$\text{rad.} \times \sin. S s = \sin. \Upsilon \times \sin. S \Upsilon,$$
$$\text{and rad.} \times \sin. X x = \sin. \Upsilon \times \sin. X \Upsilon;$$

whence, on eliminating sin. ♈, and observing that sin. X ♈ = sin. 90° = 1, we shall have

$$\sin. X x = \frac{\sin. S s}{\sin. S \Upsilon} = \frac{\sin. S s}{\cos. S X}.$$

By taking, according to the observation, S s = 23° 27′ 41″, and S X = 30′, we shall find from the logarithmic tables X x = 23° 27′ 44″·5. It will be observed that 30′ is the maximum error in longitude; if instead of 30′ it had been supposed only 3′, the corresponding error in declination would have amounted only to 0″·035. In the example chosen, the error of longitude is about 20′, whence the error of declination is 1″·5 nearly, and consequently the resulting obliquity differs little from 23° 27′ 42″·5. This result is, however, to be understood of the *apparent* obliquity, which is subject to slight variations, depending on the longitudes of the moon's nodes: the *mean* obliquity, deduced from the comparison of a great number of observations, both of the summer and winter solstice, may be regarded as amounting to 23° 27′ 41″ at the commencement of the year 1830. We shall see, when we come to speak of the *Nutation*, in what the difference between the apparent and mean obliquity consists.

When the mean value of the obliquity of the ecliptic, as determined by the delicate instruments of the present day, is compared with that given by ancient observations, it appears to have undergone a progressive diminution, and is always greater as the observation is more remote. The ancient observers were not, indeed, possessed of the means of determining an element of this sort with great precision; but as all the observations recorded in history agree in making the obliquity greater in former times than it is now, the probability is almost infinite that the angle formed by the planes of the equator and ecliptic has really diminished; for, had the differences of the values assigned to it arisen solely from errors of observation, they would have been in excess and defect indifferently, instead of being, as they are, uniformly in excess. The various observations and traditions by which the progressive diminution of the obliquity is confirmed have been collected by Bailly; in the following table we have inserted those which appear to be the best authenticated, and have added the results of some recent observations, which exhibit the present value of the obliquity, and the rate of its diminution.

Year.	Name of Observer.	Obliquity.			Year.	Name of Observer.	Obliquity.		
Before Christ.					After Christ.				
200	Eratosthenes, confirmed by Hipparchus and Ptolemy	23°	51′	15″	1690	Flamsteed	23°	28′	48″
160	The Chinese	33	45	52	1703	Bianchini	23	28	35
After Christ.					1736	Condamine	23	28	24
					1743	Cassini de Thury	23	28	26
					1750	Lacaille	23	28	19
					1755	Bradley	23	28	15
827	Arabians at Bagdad	23	33	52	1756	T. Mayer	23	28	16
880	Albategnius	23	35	40	1769	Maskelyne	23	28	10
1150	Almansor	23	33	30	1780	Cassini	23	27	54
1278	The Chinese	23	32	12	1800	Maskelyne	23	27	56·6
1437	Ulugh Beigh	23	31	58		Piazzi	23	27	56·3
1490	Walther	23	29	47		Delambre	23	27	57
1590	Tycho	23	29	52	1813	Pond	23	27	48·66
1646	Riccioli	23	30	20	1815	Bessel	23	27	47·46
1660	Hevelius	23	29	10	1816	Dr Brinkley	23	27	49·21
1672	Cassini	23	29	00	1825	Dr Pearson	23	27	44·01

Secular rate of diminution.

Although the comparison of these observations with one another gives very discordant results relatively to the law according to which the obliquity varies, their totality places the fact of its progressive diminution beyond all manner of doubt. Lacaille, who was followed by the greater number of astronomers, estimated the diminution of 44″ in a hundred years; a result to which he was led chiefly by a comparison of his own observations with those of Walther. Lalande, after comparing an immense number of modern observations with those of the 17th, 16th, and 15th centuries, and also with those of the Arabians and Chinese, found the secular diminution to be 50″. Bessel, rejecting the ancient observations as too uncertain, and comparing those only which have been made since the time of Bradley, has fixed the secular diminution at 45″·7, which differs inconsiderably from the determination of Lacaille. It cannot yet be determined by observation whether this diminution is uniform, or accelerated, or retarded; but so slow is the rate at which it proceeds, that it may, without any sensible error, be regarded as uniform for many centuries to come.

The gradual diminution of the obliquity of the ecliptic might lead us to suppose that a time will ultimately arrive when that plane will coincide with the equator, and the earth be deprived, in consequence, of the agreeable vicissitude of the seasons. But the theory of universal gravitation, which has revealed the cause of the diminution, has also shown that there are certain limits which the angle of the two planes can never exceed, and between which it must continue for ever to oscillate. Geometers have not yet ventured to assign the precise extent of these limits, but their existence is certain; and the planes of the ecliptic and equator, which have been approaching to each other during the last 2000 years, will, in the course of some thousands of years more, begin to recede.

Displacement of the ecliptic.

In what has yet been said respecting the diminution of the obliquity of the ecliptic, no fact has been mentioned from which it can be inferred, whether the phenomenon is

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occasioned by the displacement of the plane of the ecliptic or that of the equator. This question may also be decided by a comparison of modern with ancient observations; for it is evident, that if the inclination of these two planes becomes less, the stars which are situated between them, particularly those near the solstitial colure, will appear to approach to that plane which changes its position; so that if the ecliptic is displaced, the latitudes of those stars will be diminished, or their declinations if the displacement belongs to the equator. It was first observed by Tycho, and the observation has been confirmed by succeeding astronomers, that the latitudes of the southern stars situated near the solstitial colure, that is, of those stars whose longitudes are nearly 90°, have diminished upwards of 20′ since the time of Hipparchus and Ptolemy, while the latitudes of the northern stars have undergone a corresponding augmentation. From this fact it is proved that the diminution of the obliquity is occasioned by the displacement of the ecliptic; and theory has shown that the cause of the displacement is the action of the planets, particularly of Jupiter and Venus, on the earth, by virtue of which the plane of the earth's orbit is drawn nearer to the planes of the orbits of these two planets. This, however, though by far the most considerable, is not the sole cause of the phenomenon; for theory also shows that a slight motion of the plane of the equator is produced by the attraction of the sun and moon, but so very minute that its effects will only become appreciable after a long series of ages.

Precession of the Equinoxes.

After determining the inclination of the plane of the ecliptic to that of the equator, the only element requisite to fix its position absolutely in space, is the situation of the straight line formed by its intersection with that plane, that is to say, the line of the nodes. The longitudes of the stars, as has already been mentioned, are counted on the ecliptic from the vernal equinox; and therefore, if the line of the equinoxes, which is the same as the line of the nodes, is invariable, the longitude of any star will always be the same, whatever interval of time may elapse between two observations of that longitude. But on comparing the actual state of the heavens with the observations recorded by ancient astronomers, it is perceived that the longitudes of all the stars are considerably increased; whence we must infer, either that the whole firmament has advanced in the order of the signs, or that the equinoctial points have gone backwards, or retrograded. The latter supposition is infinitely the more probable; for it is inconceivable that the innumerable multitude of stars should have a common motion relatively to points which depend solely on the motion of the earth. The phenomenon is therefore to be explained by attributing to the equinoctial points a retrograde motion from east to west, in consequence of which, the sun, whose motion is direct, arrives at them sooner than if they remained at rest; and therefore the equinoxes, spring, autumn, and the other seasons, happen before the sun has completed an entire circuit. On this account the motion has been denominated the *Precession of the Equinoxes*. As this motion is extremely slow, its exact amount can be discovered only by a comparison of observations separated from each other by long intervals of time; but the imperfection of instruments prior to the sixteenth century renders the ancient observations of little authority where quantities so minute are concerned, and therefore some discrepancies may be expected in the different determinations of the amount of the precession. The comparison of modern observations with those of Hipparchus gives its annual amount equal to $50\frac{2}{3}$ seconds, and with those of Ptolemy somewhat greater. The mean result of the observations of Tycho, compared with those of Lacaille, gives $50''\frac{1}{3}$. On comparing modern observations with one another, we find $50''\cdot06$. Delambre, in his solar tables, supposes the annual precession to be equal to $50''\cdot1$. According to this estimate the equinoctial points go backwards at the rate of one degree in 71·6 years nearly, and therefore will make a complete revolution of the heavens in about 25,868, or nearly 26 thousand years.

The discovery of the precession of the equinoxes is generally attributed to Hipparchus, who, on comparing his own observations with those of Timocharis, more ancient by 160 years, perceived that in this interval the longitudes of the stars had been augmented by about two degrees. It would seem, however, from many proofs collected by Bailly, that this motion, slow as it is, was known to all the ancient nations who cultivated astronomy, long before the time of Hipparchus. It is indeed easy to conceive, from the great attention which they gave to the heliacal risings of the remarkable stars, that they might observe a gradual change of the seasons at the occurrence of these phenomena, from which they would necessarily be led to conclude a variation of the star's longitude. In consequence of this regression of the equinoctial points, the sun's place among the zodiacal constellations at any given season of the year is now greatly different from what it was in remote ages. Some time prior to Hipparchus, the first points of Aries and Libra corresponded to the vernal and autumnal equinoxes; those of Cancer and Capricorn to the summer and winter solstices: at present these constellations have receded 30 degrees from the same points of the ecliptic. The vernal equinox now happens in the constellation Pisces, the summer solstice in Gemini, the autumnal equinox in Virgo, and the winter solstice in Sagittarius. Astronomers, however, still count the signs from the vernal equinox, which, therefore, always corresponds to the first point of the *Sign* of Aries. On this account it is necessary to distinguish carefully between the *Signs* of the Zodiac, which are fixed with regard to the equinoxes, and the *Constellations*, which are movable with respect to those points.

Physical cause of the precession of the equinoxes.

The diminution of the obliquity of the ecliptic arises from the displacement of the ecliptic itself; the precession of the equinoxes is, on the contrary, occasioned by the continual displacement of the plane of the terrestrial equator. This displacement results from the combined action of the sun and moon (for the influence of the planets amounts only to a fraction of a second, and is consequently scarcely sensible,) on the mass of protuberant matter accumulated about the earth's equator, or the matter which forms the excess of the terrestrial spheroid above its inscribed sphere. The attracting force of the sun and moon on this shell of matter may be resolved into two; one parallel to the plane of the equator, the other perpendicular to it. The tendency of this last force is to diminish the angle which the plane of the equator makes with that of the ecliptic; and if the earth had no motion of rotation, it would soon cause the two planes to coincide. In consequence, however, of the rotatory motion of the earth, the inclination of the two planes remains constant; but the effect produced by the action of the force in question is, that the plane of the equator is constantly shifting its place, in such a manner that the line of the equinoxes advances in the direction of the diurnal motion, or contrary to the order of the signs, its pole having a slow angular motion about the pole of the ecliptic, so slow indeed, that it requires nearly 26,000 years to complete its revolution.

Nutation.

If the sun and moon moved in the plane of the equator, there would evidently be no precession; and the effect of

their action in producing it varies with their distance from that plane. Twice a year, therefore, the effect of the sun in causing precession is nothing; and twice a year, namely at the solstices, it is a maximum: on no two successive days of the year is it exactly the same, and consequently the regression of the equinoctial points, which results from the sun's action, must be unequable. On this account the obliquity of the ecliptic is subject to a semi-annual variation; for the sun's force, which tends to produce a change in the obliquity, is variable, while the diurnal motion of the earth, which prevents the change from taking place, is constant. Hence the plane of the equator is subject to an irregular motion, which is technically called the *Solar Nutation.* The existence of the solar nutation is, however, only a deduction from theory, for its amount is too small to be perceptible to observation; but a similar effect of the moon's action is sufficiently appreciable, and was, in fact, discovered by Dr Bradley before theory had indicated its existence. Its period, however, is different, and depends on the time of the revolution of the moon's nodes, which is performed in 18 years and about 7 months. During this time the intersection of the lunar orbit with the ecliptic has receded through a complete circumference; and the inequality of the moon's action will consequently, in the same time, have passed through all its different degrees. Bradley observed that the declinations of the stars continued to augment during nine years, that they diminished during the nine years following, and that the greatest change of declination amounted to 18″. He remarked further, that this motion was connected with an irregularity of the precession of the equinoxes, which followed exactly the same period; whence he concluded that the motion of the poles of the equator, occasioned by this vibration of its plane, was not confined to the solstitial colure. A series of observations on stars differently situated proved that all the phenomena could be explained on the hypothesis that the pole of the equator describes in 18 years a small circle of 18″ diameter, contrary to the order of the signs; or that the axis of the world, following the circumference of this circle, describes the surface of a cone, the axis of which forms with its side an angle of 9″. This apparent vibratory motion is significantly denominated the *Nutation of the Earth's Axis.*

Path described in space by the pole of the equator.

Fig. 14.

In consequence of the two motions which occasion the precession and the nutation, the true path of the pole of the equator round that of the ecliptic is an epicycloidal curve, which will be understood by referring to fig. 14. Let E be the pole of the ecliptic, round which the pole of the equator P describes, in virtue of the precession, and in a direction contrary to the order of the sines, the circle PQR, of which the radius EP is equal to the obliquity of the ecliptic, or the mean distance of the two poles. While P, the mean place of the pole, moves in the circle PQR, with a velocity equal to the regression of the equinoctial points, or at the rate of 50″·1 a year, the *true* pole *p* describes at the same time round P a small circle of 18″ diameter in the same direction *pqr*. The true path of the pole is therefore along the circumference of a circle *pqr*, the centre of which retrogrades on the circumference of another circle, and consequently moves in an epicycloid *abcdefg*, the curve which results from the composition of the two motions. Suppose the mean pole at Q, the true pole at *a*, and $aQ = 9''$. In the course of nine years the mean pole will have retrograded from Q to R, making $QR = 9 \times 50''\cdot1$, while the true pole will have accomplished a semi-revolution in its circle. It will therefore be at *c* (Rc being $= 9''$), and have described the epicycloidal arc *abc*, the greatest distance of which from the circle PQR is at *b*, and equal to 9″. At the end of the following nine years the mean pole has retrograded from R to S, or $9 \times 50''\cdot1$, and the true pole has returned to the same point *a* of its epicycle; it will therefore be found at *e*, Se being $= 9''$. In this interval it has necessarily been within the circle PQR, its greatest distance from which at *d* is 9″, so that in 18 years it has traced the curve *abcde*. But $ac = QR + aQ + Rc = 9 \times 50''\cdot1 + 18'' = 7'\,49''$, and $ce = RS - Rc - Se = 9 \times 50''\cdot1 - 18'' = 7'\,13''$. From *a* to *c* the motion of the true pole in the epicycle is in the same direction as that of the mean pole; from *c* to *e* it is in an opposite direction, but as it is always much slower, being only about 3″ in a year, while that of the mean motion is 50″·1, the true motion which results from the combination of both will always be in the direction *ce*, and at *d* its velocity will be equal to their difference. At *b* and *d* the difference between the latitudes of the true and mean pole is a maximum, while the difference of their longitudes is nothing; in other words, the correction of the obliquity is greatest when that of the precession vanishes: at *a*, *c*, and *e* the correction of the obliquity vanishes, and that of the precession is a maximum.

Pole describes ellipse.

Dr Bradley remarked that the effects of the nutation would be represented still more accurately by supposing the curve described by the pole of the equator about its mean place to be an ellipse instead of a circle, the transverse and conjugate axes being 18″ and 16″ respectively. This is also confirmed by theory, from which Laplace calculated the semi-axes of the ellipse at 9″·63 and 7″·17. The semi-transverse axis of the ellipse described by the pole in virtue of the sun's action alone does not exceed half a second, and is consequently totally inappreciable. The sensible part of the nutation, therefore, follows exactly the period of the revolution of the nodes of the moon. From a series of 810 observations, embracing three complete revolutions of the moon's node, the major and minor semi-axes of the ellipse have been found by M. Lindenau to be 8″·977 and 6″·682 respectively.

It is now easy to see the reason of the distinction drawn above between the *mean* and the *true* or *apparent* obliquity. The mean obliquity is represented by the radius EP of the deferent circle PQR, along the circumference of which the centre of the small circle or ellipse is carried, while the true obliquity is that quantity increased or diminished by the nutation. The calculation of the mean obliquity from the true is performed by the aid of the astronomical tables.

The progressive diminution of the mean obliquity and the nutation of the earth's axis are inequalities distinguished from each other, not only by their being derived from different and distinct causes, but still more by the very great difference of time required for their full development. Almost every other element of the planetary system is affected in a similar manner by inequalities of two kinds, which are distinguished by the terms *secular* and *periodic.* The secular inequalities proceed with extreme slowness, and continue progressive in the same sense during many centuries; while the periodic are much more rapid in their march, and run through the whole period of their changes in comparatively short intervals of time. The inequalities of the first kind are also periodic; but their periods are vastly longer, and may be reckoned by centuries instead of years; and from this circumstance they derive their name of *secular inequalities.*

Sect. II.—*Of the Orbit of the Sun.*

Having now considered the situation of the plane in which the sun is observed to move relatively to the fixed stars, and also the small secular and periodic variations

to which it is subject, we proceed next to inquire into the nature of his orbit, or the curve which he describes on that plane. The means which we have of determining the solar orbit are the observed variations of the sun's angular velocity, and of his distance from the earth; hence two kinds of observations are necessary,—the first, of his daily meridional altitudes, from which, as the inclination of the orbit is known, his angular velocity is easily found; and the second, of his apparent diameter, the variations of which follow the inverse ratio of his distance.

That the angular velocity of the sun's motion in his orbit is not uniform, is obvious from the fact that he remains $7\frac{2}{3}$ days longer in the northern than in the southern signs, or, which is the same thing, that the interval between the vernal and autumnal equinoxes is $7\frac{2}{3}$ days longer than the interval between the autumnal and vernal. It is proved by numerous observations that the sun moves with the greatest velocity when at a point situated near the winter solstice; while at the opposite point of the orbit, or near the summer solstice, his velocity is the least. At the first point the diurnal motion is 1°·01943, and at the second only 0°·95319. It is constantly varying between these two points; and the variation is observed to be nearly proportional to the sun's angular distance from the point of his orbit where his velocity is a maximum or minimum. The mean velocity is 0°·98632, or nearly 59′ 11″, which is the rate of the sun's daily motion about the beginning of April and October.

The point of the solar orbit, which is the most remote from the earth, is called the *apogee* (απο γης, away from the earth); that which is nearest is called the *perigee* (περι γης, near the earth). The same points are also called respectively the superior and inferior *Apsis* of the orbit, and the straight line which joins them is called the *Line of the Apsides*.

Diameter of the sun.

The exact determination of the sun's diameter is a problem which engaged the earliest astronomers, but of which, before the invention of the telescope and micrometer, it was impossible to obtain a solution sufficiently accurate to make known its variations. Archimedes, by an extremely ingenious though imperfect method, demonstrated that it must be included between the limits $\frac{1}{200}$ and $\frac{1}{164}$ of a right angle, that is, between 27′ and 32′ 55″·7. The Egyptians, by observing the time which the sun takes to rise above the horizon, found it to be between a 750th and a 700th part of a circumference, that is, between 28′ 48″ and 30′ 51″·5. Aristarchus of Samos supposed it to be 30′. The precision of modern observations shows that the apparent diameter is greatest about the time of the winter solstice, and least about the summer solstice; but there is some discrepancy among the results of different astronomers with respect to its actual magnitude. According to Lalande, the greatest apparent diameter, about the end of December, is 32′ 35″·5; the least, about the end of June, 31′ 30″·5. According to the tables of Delambre, its greatest value is 32′ 35″·6, and its least 31′ 31″; the mean apparent diameter, or the diameter at the sun's mean distance, is equal to 32′ 2″·9.

From these remarks it is obvious, that if the orbit of the sun be a circle, the earth is not situated in the centre of that circle, otherwise the distance of the sun from the earth would remain always the same, which is contrary to fact. It is possible, however, that the variation in his angular velocity may not be *real*, but only apparent. Thus, in fig. 15, let AMPN be the orbit of the sun, C the centre of that orbit, and E the position of the earth at some distance from the centre. It is obvious that P is the sun's perigee, and A his apogee. Now, as the sun's apparent orbit is a circle having the earth in its centre, it is evident that this orbit must be *a*M*p*N, and that the angular motion of the sun will be measured upon that circle. Suppose now that the sun in his apogee moves from A to A′, it is obvious that his apparent or angular motion will be the segment *a a′* of the apparent orbit, considerably smaller than AA′; so that at the apogee the angular motion of the sun will be less than his real motion. Again, let the sun in his perigee move from P to P′, describing a segment precisely equal to the segment AA′. This segment, as seen from the earth, will be referred to *p p′*, which in that case will be the sun's angular motion, evidently considerably greater than his real motion.

Hence it is obvious, that even on the supposition that the sun moved equably in his orbit, his angular motion as seen from the earth would still vary, that is, would be smallest at the apogee and greatest at the perigee, and that the angular and real motion would only coincide in the points M and N, where the real and apparent orbits intersect each other. From the figure, it is obvious also that the angular velocity would increase gradually from the apogee to the perigee, and diminish gradually from the perigee to the apogee, which likewise corresponds with observation.

Sun's motion varies.

But if the variation in the angular motion of the sun were owing alone to the eccentric position of the earth within the solar orbit, it is easy to demonstrate that in that case the diminution of his angular velocity would follow the same ratio as the diminution of his diameter. The fact however is, that the angular velocity diminishes in a ratio twice as great as the diameter of the sun does. The variation of the angular velocity cannot then be owing to the eccentricity alone. Hence it follows that the variation of the motion of the sun is not merely apparent, but real, and that its velocity in its orbit actually diminishes as his distance from the earth increases. Two causes, then, combine to produce the variation in the sun's angular velocity; namely, 1. the increase and diminution of his distance from the earth, and, 2. the real increase and diminution of his velocity in proportion to this variation of distance. These two causes combine in such a manner that the daily angular motion of the sun diminishes as the square of his distance increases, so that the product of the angular velocity multiplied into the square of the distance is a constant quantity.

The observation, that the sun's angular motion in his orbit is inversely proportional to the square of his distance from the earth, is due to Kepler. The discovery was made by a careful comparison of the sun's diurnal motion with his apparent diameter, which is inversely proportional to his distance from the earth. Let ASB (fig. 16) be the sun's orbit, E the earth, and S′ the sun. Suppose a line ES joining the centres of the earth and sun to move round along with the sun. It is obvious that when S moves to S′, ES, moving along with it, is now in the situation ES′, having described the small sector SES′. In the same time that S performs one revolution in its orbit, the radius vector ES will describe the whole area ABS inclosed within the sun's orbit. Let SS′ be the sun's angular motion during one day. It is evident that the small sector SES′ is proportional to the square of ES, multiplied by SS′; for the radius vector is the sun's distance from the earth, and SS′ his angular motion. Hence this sector is a constant quantity, whatever the angular motion of the sun be; and the whole area SEA increases as the number of days which the sun takes in moving from S to A. Hence results that remarkable law, first pointed out by Kepler, that *the areas described by the radius vector are proportional to the times of description.* Suppose the sun to describe SS′ in one day, and SA in twenty days; then

Fig. 16.

Describes areas proportional to the times.

the area SES′ is to the area SEA as 1 to 20, or the area SEA is 20 times greater than the area SES′.

The knowledge of these facts enables us to draw upon paper, from day to day, lines proportional to the length of the radius vector of the solar orbit, and having the same relative position. If we join the extremity of these lines, by making a curve pass through them, we shall perceive that this curve is not exactly circular. Let E (fig. 17) represent the earth, and E *a*, E *b*, E *c*, E *d*, E *e*, &c. the position and length of the radius vector during every day of the year; if we join together the points *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *l*, *m*, *n*, *o*, by drawing the curve *a e i m* through them, it is obvious that this curve is not a circle, but elongated towards *a* and *i*, the points which represent the sun's greatest and least distance from the earth. The resemblance of this curve to the ellipse induced Kepler to compare them together; and he ascertained their identity, and thus proved that the orbit of the sun is an *ellipse*, having the earth in one of its foci.

Fig. 17.

Having arrived at the knowledge of the true nature of the sun's orbit, it becomes necessary, in the next place, to determine its position on the plane of the ecliptic, that is, to assign the position of the transverse axis, or line of the apsides, with reference to some other straight line given by position on that plane. The line which it is most convenient to assume for this purpose is the line of the equinoxes; and the position of the apsides may be determined from observations of the time which the sun occupies in performing a semi-revolution, counting from different points of his orbit. Thus, if among the observations of the sun's longitude made daily during the course of a year, we compare, two and two, all those which are diametrically opposite, or which differ by 180°, it will be found that the interval between them will be somewhat less than half a year, if the sun, during that interval, has passed through his perigee, or longer if he has passed through his apogee; and that the time between the two observations will differ less from half the time of a whole revolution, in proportion as the sun's place, at the time of the two observations, was nearer to the apsides. If the difference of time between the two observations is exactly half a year, then the place of the apsides would be obtained at once, because the sun must have been in those points when the observations were made. The probability is, however, infinitely small, that this can ever happen exactly; but as the position of the apsides is known very nearly from the diurnal observations of the variation of the sun's angular velocity, the necesssary corrections can easily be supplied by computation.

From the comparison of observations made in different ages, it appears that the position of the apsides is not fixed on the plane of the ecliptic, but that the greater axis of the solar ellipse revolves in the direction of the sun's annual motion. The observations of Hipparchus, compared with those of the present times, show that the apsides have a direct motion at the rate of 65″ in a year. According to the observations of Walther, the longitude of the apogee in 1496 was 93° 57′ 57″; and according to Lacaille, the same element in 1750 was 98° 37′ 28″; whence, dividing the difference by 254, the interval between the two epochs, the annual motion of the line of the apsides amounts to 66″. Delambre found, by the comparison of a great number of modern observations, that the annual motion is 61″·95 a year. The theory of attraction, which, in respect of such slow and minute variations, must be considered as giving more accurate results than can be obtained directly by observation, gives 61″·9 for the yearly progressive motion of the apsides.

In the above determination, the position of the apsides is referred to the line of the equinoxes, and their motion compared with the sun's tropical revolution. But if we wish to determine their motion with reference to the fixed stars, it is necessary to have regard to the retrograde movement of the equinoctial points; for it is obvious, that if the line of the equinoxes is not fixed, the displacement of the apsides with respect to the stars will be increased or diminished by the whole amount of its motion, according as the two motions are in the same or opposite directions. Now the motion of the line of the apsides is direct, and has just been stated to amount to 61″·9 in a solar year; that of the equinoxes is, on the contrary, retrograde, and amounts to 50″·1 in the same time. Hence the displacement of the apsides, with reference to a star or fixed point in the ecliptic, is 61″·9 — 50″·1 = 11″·8 a year, in the direction of the sun's annual motion. The time, therefore, in which the solar perigee completes a revolution in the heavens, or returns to the same star, is $\frac{360°}{11''\cdot 8}$, equal nearly to 110,000 years.

Since the greater axis of the solar ellipse has a progressive motion on the plane of the ecliptic, it forms a variable angle with the line of the equinoxes, and at distant epochs will coincide with that line, or be perpendicular to it. The epochs at which these phenomena happen may be easily found by simple proportions, when the longitude of the perigee at any given time, and its annual motion, are known. According to the observations of Lacaille, already quoted, the longitude of the perigee in 1750 was 278° 37′ 28″; but when the longitude of the perigee was 270°, the greater axis of the solar ellipse must have been perpendicular to the line of the equinoxes. The difference of these two longitudes is 8° 37′ 28″, and the number of years requisite to describe that arc, at the rate of 61″·9 annually, is $\frac{8° 37' 28''}{61''\cdot 9} = 500$ years nearly; whence the major axis was perpendicular to the line of the equinoxes in the year 1250, when the perigee of the orbit coincided with the winter solstice.

Suppose it were required to assign the epoch at which the major axis coincided with the line of the equinoxes. At the occurrence of this phenomenon the longitude of the perigee was 180°, consequently from that time to 1750 the perigee had advanced 278° 37′ 28″ — 180° = 98° 37′ 28″. Now $\frac{98° 37' 28''}{61''\cdot 9} = 5735$; therefore 5735 is the number of years intervening between the occurrence of the phenomenon and 1750. Hence about 4000 years before the commencement of our era, the transverse axis of the solar orbit coincided with the line of the equinoxes; and it is a singular coincidence that this epoch is considered by chronologists to be that of the beginning of the world, or, to speak more correctly, of the first traces of the existence of the human race; for numerous physical circumstances attest that the earth itself has existed during an infinitely longer period. The same phenomenon will again occur when the longitude of the perigee shall have reached 360°, or become zero; and by calculating as above, this will be found to take place in the year 6485 of our era. The solar perigee will then coincide with the vernal equinox; in the former case it coincided with that of autumn.

By reason of the progressive motion of the perigee, the length of the seasons is continually varying. Let AP (figs. 18, 19, 20) represent the line of the apsides, S and W the summer and winter solstices, V and O the vernal and autumnal equinoxes. When the greater axis was perpendicular to the line of the equinoxes, as happened in the year 1250 of our era, the perigee P (fig. 18) coincided

Fig. 1

with W the winter solstice; and on that account the time between the autumnal equinox O, and the winter solstice W, was equal to the time between W and V, or between the winter solstice and the vernal equinox. But in this position the equator, which is here represented by VO, divides the ellipse into two unequal portions, the smaller of which must be described in less time than the greater, because the times of description are proportional to the spaces passed over. The summer was therefore, at that time, longer than the winter, and both were divided into equal parts by the solstices. In any other position the seasons differ in length from each other. In the time of Hipparchus, the longitude of the perigee was less than in 1750 by 32°·292, or was 246°·330. The position of the ellipse with regard to the equinoxes was therefore such as is represented in fig. 19, the angle PEW being 270° — 246°·33 = 23° 40′ 12″. The interval between V and S was then 94½ days, and that between S and O only 92½ days. The spring was therefore at that time longer than the summer, and the winter longer than the autumn. The position of the ellipse in 1800 is represented in fig. 20. The angle PEW was then 9° 29′, and the following were nearly the lengths of the seasons:—

Fig. 19.

Fig. 20.

	Days.	Hours.	Min.
from V to S	92	21	45
S to O	93	13	35
O to W	89	16	47
W to V	89	1	42
length of the year, nearly	365	5	49

The spring is therefore at present shorter than the summer, and the autumn longer than the winter.

Eccentricity of the solar orbit.

After describing the position of the transverse axis of the solar ellipse on the plane of the ecliptic, we come next to consider the species of that ellipse, or its eccentricity, on which depend the apparent inequalities of the sun's angular motion. It is evident that this element will be made known if we can by any means determine the ratio of the two segments into which the major axis is divided by the focus. This ratio might seem to be obtainable without any difficulty by comparing the sun's apparent diameters at the perigee and apogee, to which the distances are inversely proportional; but such observations, on account of the irradiation and other difficulties, are liable to considerable uncertainty: it is therefore necessary to have recourse to other methods of estimating the eccentricity, and the variations to which it is subject. These methods are derived from the fundamental law of the elliptic motion, namely, the proportionality of the areas described by the radius vector to the times of description, by which the inequalities of motion and the ellipticity of the orbit are connected with each other; so that when the inequalities are made known by direct observation, the species of the ellipse can be computed from the principles of geometry. It will, however, be necessary to attend more closely than we have yet done to the phenomena resulting from the eccentric position of the earth in the sun's orbit, and to explain some terms technically employed by astronomers to abbreviate and simplify their descriptions.

The sun's motion may be regarded as composed of two distinct parts, namely, a circular uniform motion, which constitutes the principal part of it; and a correction depending on the deviation of the orbit from a circle, which modifies the first, and alternately accelerates and retards the mean angular velocity. To illustrate this, let E (fig. 21) be the earth, PSA the orbit of the sun, AP the line of the apsides, and ♈ ♎ the intersection of the plane of the orbit with that of the equator. While the true sun S moves round his elliptic orbit, describing areas proportional to the times, conceive a fictitious sun *s* to move round the earth in the circumference of a circle of which the radius is equal to EP the sun's distance at the perigee, and with a uniform motion such, that if the two suns set out at the same instant from P, they may also return to the same point together, after having completed each a revolution. At the perigee the radius vector of the real sun is a minimum; his velocity is consequently a maximum, and he therefore advances before the fictitious sun. But his motion relaxes in proportion as his distance from P becomes greater; and at a certain point S of the orbit it becomes equal to that of the fictitious sun, which has then only reached the point *s*. After passing the point S, the angular distance SE*s* continues to diminish on account that the motion of the real sun continues to relax, and it vanishes altogether when he reaches his apogee at A, the fictitious sun arriving at *a* in the same straight line with A and E at the same instant of time. From the apogee to the perigee the phenomena are reversed. The motion of the real sun being then the slowest possible, he at first falls behind the fictitious sun; but his motion continuing to be gradually accelerated, he has again acquired the same velocity when he reaches S′, after which his motion is more rapid than that of the fictitious sun, which he at last overtakes at P. If, therefore, we conceive a radius vector to be drawn from the earth to each of the two suns, those lines will form with each other a variable angle, having its maximum value when the velocities are equal, and vanishing at the perigee and apogee. This angle, namely, SE*s*, is called the *Equation of the Centre*, or *Equation of the Orbit*. It is the correction necessary to be made to the longitude of the sun deduced from his equable motion, in order to have his real longitude. Those quantities which form the difference between the true and mean results are, in astronomy, denominated equations. The ancients employed the term *Prosthaphæresis* in the same sense.

Fig. 21.

Equation of the centre.

From the perigee to the apogee, the true longitude of the sun is found by adding the equation of the centre to the mean longitude, and in the other half of the orbit by taking the difference of the same quantities. The equation of the centre is a maximum when the sun is at the points S and S′, or when the mean and true motions are equal; and if its value can be obtained from observation at those times, the eccentricity of the orbit may be deduced by means of the geometrical properties of the ellipse. Now the points S and S′ may be found very nearly by observing when the diurnal velocity of the sun is equal to the mean motion, or to 0·985647 parts of a degree. By these observations the angle SES′, which is the difference of the real longitudes of the sun, or of his distances from ♈, will be given. But *s* E *s*′ is also given; for it is the angle which would be described by the sun, in virtue of his mean motion, during the interval between the two observations. Hence the difference between *s*E*s*′ and SES′ is given, being equal to twice SE*s* the maximum equation of the centre, in consequence of the symmetrical position of the points S and S′, and also of *s* and *s*′, in respect of the line of the apsides AP. The accuracy of a result obtained in this manner may appear questionable, on account of the impossibility of determining by observation the exact moment at which the sun's true motion in longitude is equal to his mean motion; but as the real motion varies very little during a few days before and after that epoch, the equation of the centre will be scarcely affected by a slight error in the time. Besides, any error in the result is corrected by taking the mean of a great number of similar observations.

Theoretical Astronomy.

By a comparison of numerous observations of this kind, Delambre found that the greatest equation of the centre, in the year 1776, amounted to 1°·9254, or 1° 55′ 31″·4. In 1801 the same equation was 1° 55′ 27″·3. (See Baily's *Astronomical Tables*, p. 66.)

Having obtained the value of the greatest equation of the centre, the eccentricity of the orbit may be computed from the first two terms of the following series,

$$e = \tfrac{1}{2}\mathrm{E} - \frac{11}{2^4 \cdot 3}\mathrm{E}^3 - \frac{587}{2^{16} \cdot 3 \cdot 5}\mathrm{E}^5 - \&c.$$

in which e represents the eccentricity, and E the greatest equation of the centre. By reversing the series the following expression is found for the greatest equation in terms of the eccentricity, viz.

$$\mathrm{E} = 2e + \frac{11}{2^4 \cdot 3}e^3 + \frac{599}{2^{10} \cdot 5}e^5 + \&c.$$

For an investigation of the above formulæ the reader may consult Biot, *Astronomie Physique*, tom. ii. p. 185.

Secular diminution of the eccentricity of the solar orbit.

It has been discovered by observation, that the equation of the centre of the sun's orbit is subject to a nearly uniform secular diminution. This fact is confirmed by theory, from which also the secular diminution has been assigned. It amounts to 8°·0047 in a century. This phenomenon implies a corresponding diminution of the eccentricity of the solar orbit amounting to ·000037495 in the same time, the semiaxis major being unit. This will be conceived more distinctly by converting the above fraction into some familiar expression of linear magnitude. Supposing the mean distance of the sun to be 96,000,000 of miles, the fraction ·000037495 will represent nearly 3700 miles, so that the annual diminution of the eccentricity is nearly at the rate of 37 miles,—a line which is considerable on the surface of the earth, but which has scarcely an appreciable ratio to the immense distance of the sun. If, however, this diminution, small as it is, were to be continued indefinitely, the eccentricity would ultimately vanish, and the sun's orbit would be changed into a circle; but the theory of universal gravitation proves that, like all the other variations of the elements of the solar system, the variation of the eccentricity is subject to periodic laws. After having continued during a certain time to diminish, the eccentricity will again begin to increase, and will successively pass through all its former values. Thus it will continue to oscillate within certain limits, of which the extent, though not precisely known, cannot be very great: and the solar orbit will eternally preserve its elliptic form, unless the application of some external force shall derange the system of the world, or modify the laws by which it is at present governed.

Determination of the sun's place in his orbit.

Kepler's problem.

The true nature of the solar orbit being known, together with its situation on the plane of the ecliptic, and the amount of its eccentricity, as also the time of a revolution, the sun's longitude may be determined at any assigned epoch. This determination is what is usually termed *Kepler's Problem*, having been first proposed by that great astronomer on the hypothesis of an elliptic orbit. Its solution, which is not susceptible of being exhibited under a finite form, is derived from the principle of the equable description of areas. Let ASP (fig. 22) represent the semi-orbit of the sun, C the centre of the orbit, E the focus occupied by the earth, and let the time and motion be counted from the perigee P. On AP describe a semicircle, on the circumference of which let a point M be supposed to move uniformly, and to describe the semicircle PMA, in the same time in which the sun describes the semi-ellipse PSA. Now, suppose that at the end of a given time t, the sun has moved from P to S; then, denoting by T the time of a complete revolution, and putting π for the semi-circumference, the place of M, at the end of the same time t, will be given by the equation $\mathrm{PM} = \frac{t}{\mathrm{T}} 2\pi$. Through S let a perpendicular be drawn to AP, meeting the semicircle in D and AP in N, and join EM, ES, ED, CM, and CD. The different angles of this figure have received certain technical names, which it is necessary to explain. The angle PES, which is the *true* longitude of the sun, is called the *True Anomaly;* PEM is called the *Mean Anomaly*, and PCD is denominated the *Eccentric Anomaly*. This last is measured by the arc PMD, which is the perigean distance of a star describing a circle circumscribed about the solar ellipse, and having constantly the same absciss PN as the sun. The word *anomaly* originally signified *inequality;* it now simply designates the angular distance of a planet from its perihelion, seen from the sun, or, as in the present case, the angular distance of the sun from his perigee.

Theoretical Astronomy. Fig. 22.

According to the law of the equable description of areas, we have the sector PCM to PES as the surface of the semicircle to the surface of the semi-ellipse; that is, as the semi-transverse to the semi-conjugate axis, or as ND to NS, according to a well-known property of the ellipse. Hence PCM : PES : : PED : PES, and therefore PCM = PED = PCD — ECD. Now, if we express the arc PM by z, PD by x, the eccentricity EC by e, and make the radius equal to unity, we shall have the sector $\mathrm{PCM} = \frac{1}{2}z$, the sector $\mathrm{PCD} = \frac{1}{2}x$, and the triangle $\mathrm{ECD} = \frac{1}{2}e.\ \mathrm{DN} = \frac{1}{2}e \sin. x$. Substituting, therefore, these expressions in the above equation, it will become, on multiplying both sides of it by 2,

$$\mathrm{Z} = x - e \sin. x \ldots\ldots\ldots\ldots\ldots (1.)$$

where z denotes the mean, and x the eccentric, anomaly.

If in this equation x and e were both known, it would be easy to deduce from it the mean anomaly z; but the data are z and e, and the value of x can only be obtained in a series, the equation being a transcendental one. Its resolution gives the value of the eccentric in the mean terms of anomaly; and if another equation can be found in which the eccentric anomaly is expressed in terms of the true, it will only remain to put these two expressions equal to one another in order to have an equation between the mean and true anomaly.

For this purpose it will be necessary to equate two values of the radius vector ES, expressed in terms of the eccentric and true anomalies respectively. Putting ES $= r$, we shall have, in the first place,

$$r^2 = \mathrm{EN}^2 + \mathrm{NS}^2;$$

but if the semiaxis minor is represented by b, the common equation of the ellipse gives

$$\mathrm{NS}^2 = \frac{b^2}{a^2}(a^2 - \mathrm{CN}^2) = b^2 - \frac{b^2}{a^2}\mathrm{CN}^2;$$

and we have also

$$\begin{aligned}\mathrm{EN}^2 &= \mathrm{EC}^2 + 2\,\mathrm{EC}\,.\,\mathrm{CN} + \mathrm{CN}^2\\ &= e^2 + 2e\,.\,\mathrm{CN} + \mathrm{CN}^2;\end{aligned}$$

therefore, by addition,

$$\mathrm{NS}^2 + \mathrm{EN}^2 = b^2 + e^2 + 2e\,.\,\mathrm{CN} + \left(1 - \frac{b^2}{a^2}\right)\mathrm{CN}^2.$$

Now, $b^2 + e^2 = a^2$, and $1 - \frac{b^2}{a^2} = \frac{e^2}{a^2}$; therefore

$$\mathrm{NS}^2 + \mathrm{EN}^2 = r^2 = a^2 + 2e\,.\,\mathrm{CN} + \frac{e^2}{a^2}\mathrm{CN}^2;$$

consequently

$$r = a + \frac{e}{a}\mathrm{CN}.$$

But $\mathrm{CN} = a \cos. x$; therefore ultimately

$$r = a + e \cos. x \ldots\ldots\ldots\ldots\ldots\ldots (2.)$$

To obtain a second value of r, let SF be drawn from S to the other focus of the ellipse, and let $SF = r'$. The rectangular triangles ESN, FSN give $SN^2 = r^2 - EN^2$, and $SN^2 = r'^2 - (2e - EN)^2$; therefore $r^2 - EN^2 = r'^2 - (2e - EN)^2$, whence we derive $r^2 - r'^2 = 4e \cdot EN - 4e^2$. But by the property of the ellipse $r + r' = 2a$, from which it is easy to deduce $r^2 - r'^2 = 4a^2 - 4ar' = 4ar - 4a^2$; and hence, by equating these two values of $r^2 - r'^2$, $e \cdot EN - e^2 = ar - a^2$. Now, if we denote the angle PES, which is the true anomaly, by v, then $EN = r \cos. v$, and consequently by substitution, $er \cos. v - e^2 = ar - a^2$, whence

$$r = \frac{a^2 - e^2}{a - e \cos. v} \text{.....(3.)}$$

If we now compare the two values of r given by the equations (2) and (3), we shall find

$$\cos. x = \frac{a \cos. v - e}{a - e \cos. v},$$

and therefore, $1 - \cos. x = (a + e)(1 - \cos. v)$

$$1 + \cos. x = (a - e)(1 + \cos. v);$$

whence, by dividing,

$$\frac{1 - \cos. v}{1 + \cos. v} = \frac{a - e}{a + e} \cdot \frac{1 - \cos. x}{1 + \cos. x};$$

consequently, by the trigonometrical formulæ,

$$\tan. \tfrac{1}{2}v = \left(\frac{a - e}{a + e}\right)^{\frac{1}{2}} \cdot \tan. \tfrac{1}{2}x \text{..... (4.)}$$

The equations (1) and (2) were first given by Kepler; the last is due to Lacaille. The problem of finding the sun's place after any given time is solved analytically by (1) and (4).

To express v the true anomaly, in a series involving the powers of x the mean anomaly, is a problem requiring the aid of the higher analysis, and which it is unnecessary to investigate here. The following are a few of the first terms of the series, in which nt is substituted for x, n being the mean motion in the unit of time, and t the time elapsed since the passage through the perihelion :—

$$v = nt - \left(2e - \tfrac{1}{4}e^3 + \frac{5}{96}e^5\right) \cdot \sin. nt$$
$$+ \left(\frac{5}{4}e^2 - \frac{11}{24}e^4 + \frac{17}{192}e^6\right) \sin. 2nt$$
$$- \left(\frac{13}{12}e^5 - \frac{43}{64}e^7\right) \sin. 3nt$$
$$+, \&c.$$

The form of the sun's orbit is discovered from the variations of his apparent diameter in passing from the perigee to the apogee; but in order to obtain a knowledge of its real dimensions, or of the mean distance of the sun from the earth, it is necessary to determine his parallax, that is to say, the angle subtended by the earth's semidiameter as seen from the sun. This angle is too small to be measured directly in the manner which was pointed out when treating of parallax; it is most accurately deduced from observations of the time occupied by an inferior planet in passing over the sun's disk, as will be explained afterwards. From such observations it has been found to be less than 9″, an angle of which the sine is to radius in the ratio of 1 to 23,000 nearly; whence the distance of the sun is about 23,000 times the semidiameter of the earth. The following table exhibits more accurately the numerical results of calculation.

DISTANCE OF THE SUN FROM THE EARTH.

	Semidiameters of the Earth.	English Miles.
In Perigee.....	23580	93280945
In Apogee.....	24388	96478967
At Mean Distance.....	23984	94879956
Greatest diameter of his orbit	47969	189764357

When the sun's parallax is known, we are enabled not only to estimate his distance, but also to compare his diameter and magnitude with those of the earth. For example, the mean parallax of the sun is 8″·56; his mean apparent semidiameter, seen from the earth, is 961″·4; the semidiameter of the sun and earth are therefore to each other in the ratio of 961·4 : 8·56, or of 112 to unity nearly. Supposing the sun and earth to be both spherical bodies, which is a supposition sufficiently accurate for the present purpose, their volumes will be to one another as the cubes of their radii; hence the volume of the sun is to that of the earth as the cube of 112 to unity, or the sun's volume is about 1,300,000 times greater than that of the earth.

Sun's volume.

Sect. III.—*Of the Motion of Translation of the Earth, and the Aberration of Light.*

Hitherto we have regarded the sun as being actually in motion round the earth in an elliptic orbit, of which the earth occupies one of the foci. This supposes the motion which we observe to be real. But we have already seen that all the phenomena of the diurnal revolution of the celestial bodies may be equally well explained by supposing these motions to be only optical illusions, of the same nature as those by which a person sailing rapidly along a river, or the sea-shore, is almost irresistibly led to ascribe the motion to the banks on the shore, even when fully aware that the appearance is only occasioned by his own motion in a contrary direction. In the same manner all the phenomena of the annual motion are susceptible of an equally simple explanation, on the hypothesis that the earth revolves in an elliptic orbit, and that the sun is at rest in one of the foci of the ellipse. In fact, if there were no other bodies in the universe than the earth and the sun, it would be matter of absolute indifference which of the two hypotheses we should adopt in order to explain the appearances. Supposing, for example, the earth to revolve in a circular orbit (the eccentricity, on account of its smallness, being here neglected), and the sun to be placed at the centre; a spectator at E (fig. 23) sees the sun S in the heavens at the point A, and corresponding to the star a on the celestial sphere. If the earth now take the place of the sun, and the sun be placed on the curve at A, the spectator will still see the sun correspond to the star a. Let the earth be transferred from E to E′; the spectator will then see the sun in A′. The sun therefore appears to him to have moved from A to A′, which is exactly the same appearance as would be presented to a spectator at the centre by a real translation of S from A to A′; so that, in respect of the annual motion, the appearances, when referred to the celestial sphere, are precisely the same on either hypothesis. Fig. 23.

If we now consider the phenomena with reference to the earth, we shall find that they may be all equally well explained on the hypothesis of the earth's motion, and the immobility of the sun. The most remarkable phenomenon connected with the annual revolution is the variation of the seasons; and in order to explain their cause, it is only necessary to suppose that the earth, in describing its oblique orbit, always preserves its axis parallel to the same straight line. Let A, B, C, D (fig. 24) repre- Fig. 24.

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sent the earth in four different positions of its orbit, *n s* being its axis, and *n* and *s* its north and south poles respectively. While the earth goes round the sun in the order of the letters A, B, C, D, its axis *ns* preserves its obliquity, and always continues parallel to its first direction. At A the north pole inclines towards the sun, and brings all the northern places more into the light than at any other season of the year. But when the earth is at C, the opposite point of the orbit, the north pole declines from the sun, and a less portion of the northern hemisphere enjoys the blessings of his light and heat. At B and D the axis is perpendicular to the plane of the orbit, so that the poles are situated in the boundaries of the illuminated hemisphere, and the sun, being directly over the equator, makes the days and nights equal at all places. These phenomena are illustrated in fig. 25, which represents the situation of the north pole with regard to the limits of illumination, in eight different positions of the orbit. In this figure, Æ is the terrestrial equator, T the tropic of Cancer, the dotted circle the parallel of London, U the arctic or north polar circle, and P the north pole, where all the meridians or hour-circles meet. The spectator is supposed to be placed at the pole of the ecliptic.

Plate LXXXI. Fig. 25.

When the earth is at the beginning of Libra, about the 20th of March, the sun, as seen from the earth, appears at the beginning of Aries in the opposite part of the heavens, the north pole is just coming into light, and the sun is vertical to the equator, which, with all its parallels, is divided into two equal parts by the circle which forms the boundary between the dark and illuminated hemispheres, and therefore the days and nights are equal all over the earth. As the earth moves in the ecliptic according to the order of the letters A, B, C, D, &c., the north pole P comes more and more into the light, and the days increase in length at all places north of the equator Æ. When the earth comes to the position between B and C, or the beginning of Capricorn, the sun, as seen from the earth, appears at the beginning of Cancer, about the 21st of June; and the north pole of the earth inclines towards the sun, so as to bring into light all the north frigid zone, and more of each of the northern parallels of latitude in proportion as they are farther from the equator. As the earth advances from Capricorn towards Aries, and the sun appears to move from Cancer towards Libra, the north pole recedes from the light, which causes the days to decrease and the nights to increase in length, till the earth comes to the beginning of Aries, and then they are equal as before; the boundary of light and darkness cutting the equator and all its parallels equally. The north pole then goes into the dark, and does not emerge till the earth has completed a semi-revolution of its orbit, or from the 23d of September till the 20th of March. All these phenomena will be readily understood from the bare inspection of the figure; and it will be perceived that what has been said of the northern hemisphere is equally true of the southern in a contrary sense, that is, at opposite seasons of the year.

The only objection against the annual motion of the earth, which at first sight creates some difficulty, is the enormous distance which, on account of the want of annual parallax, that hypothesis makes it necessary to assign to the fixed stars. Abstracting from the precession, which in the region of the poles amounts only to about 20″, the axis of the earth, in every part of its orbit, appears to be directed towards the same point of the starry sphere. It is certain, however, that the radius of the terrestrial orbit is upwards of 90 millions of miles; and therefore, when the earth is at opposite points of this immense circle, its pole ought to be directed to points in the heavens 180 millions of miles distant from each other. Suppose the sun to be at rest in S (fig. 26), the centre of the orbit E*ab*, and the earth to be at the point E. Suppose also A to be the projection of S on the sphere of the fixed stars, and ♈ the first point of the ecliptic. The longitude of A, as seen from E, is the angle AE♈; but when seen from S, the longitude of the same point is AS♈. This last is the *true* longitude of A; AE♈ is the *apparent* longitude, and their difference is the angle S♈E. Now, in the first half of the ecliptic, the apparent longitude will be less than the true, and in the second half greater; hence there ought to result an apparent annual inequality in the sun's longitude. But as no such inequality is indicated by observation, it becomes necessary either to abandon the hypothesis of the earth's motion, or to suppose the distance of the fixed stars to be so great, that, in comparison of it, the radius ES, which exceeds 90 millions of miles, is altogether insensible; and that the whole orbit of the earth, or the ellipse E*ab*, is a mere point in comparison of a great circle of the starry sphere.

Theoretical Astronomy. Fig. 26.

The most convincing proof of the earth's motion is not to be found in any circumstance of which the senses can take immediate cognizance, but is afforded by the full development of the planetary system, and the mutual connection of all the truths of rational astronomy,—by the clearness, simplicity, and coherence which this hypothesis gives to the most complicated phenomena,—and can therefore only be fully appreciated after an attentive study of the whole series of facts which astronomy makes known. There exists, however, one direct proof of the earth's annual motion, in a phenomenon discovered by the accurate observation and patient sagacity of Bradley, although it is one which, we are almost tempted to think, ought to have been perceived *a priori*, after Roemer's discovery of the progressive motion of light. It is known by the name of the *Aberration of Light*, and is manifested in a small difference between the apparent and true places of a star, occasioned by the motion of light combined with that of the earth in its orbit.

Aberration of light.

To illustrate this effect, conceive a body to move in the direction EE′ (fig. 27), and another to impinge on it in the direction SE. To find the direction of the resulting motion, take EC and EA proportional to the two velocities respectively, and, having completed the parallelogram EABC, draw the diagonal EB. The combination of the two motions produces an impression on the eye exactly similar to that which would have been produced if the eye had remained at rest in the point E, and the molecule of light had come to it in the direction ES′; the star, therefore, whose real place is at S, will appear to the spectator at E to be situated at S′. The difference between its true and apparent place, that is, the angle SES′, is the *aberration*, the magnitude of which is obtained from the known ratio of EA to EB, or the velocity of light to that of the earth in its orbit. Now, we know from the phenomena of the eclipses of Jupiter's satellites, that a ray of light describes a line equal to the mean radius of the ecliptic in 8 min. 13·2 sec. or 493·2 seconds of time. But the arc described by the earth in that time is found from the proportion

Fig. 27.

$$365^{d}\cdot256 : 493^{s}\cdot2 :: 360^{\circ} : x,$$

whence $x = 20''\cdot25$. It is evident, therefore, that when the directions of the two motions are at right angles, the star S always appears in advance of its real place, in a direction parallel to that of the motion of the earth, by a quantity equal to 20″·25. This quantity, 20″·25, is called the *Constant of Aberration;* but as it has been obtained on the assumption that the earth moves uniformly in a circular orbit, it is evidently not altogether exact, and recourse

must be had to observation to determine its precise amount. Bradley supposed it to be 20″; Dr Brinkley, from the mean of 2633 comparisons of various stars, has deduced the value 20″·37. From a series of 2000 observations of circumpolar stars, made for the purpose with the utmost care at the Greenwich Observatory by Mr Richardson, its value was found to be 20″·302. On account of the number and accuracy of these observations, the constant of aberration may be regarded as one of the best determined elements of astronomy. (See *Memoirs of the Astronomical Society*, vol. iv.)

It is easy to see that, on the same principles, there ought also to be a diurnal aberration; but the diurnal rotation of the earth being sixty-five times less rapid than the orbital motion, its effect in producing aberration does not amount to more than 0ˢ·0208, when reduced to seconds of time. It is consequently altogether insensible in the observations.

The magnitude of the angle of deviation SES′ depends on the relative directions of the earth and the visual ray, and may have any value from 0 to 20″·3. Suppose, for example, we observe a star situated in the plane of the ecliptic. When the earth is at that point of its orbit, between the sun and the star, where the tangent to the orbit is perpendicular to the visual ray (which, on account that the star has no sensible parallax, always maintains a parallel direction), the apparent place of the star will be 20″·3 to the eastward of its true place. When the earth is in the opposite point of its orbit the same star will appear to be 20″·3 to the westward of its true place; so that it will appear to have an oscillatory motion on the ecliptic, the range of which is 40″·6, and the period exactly a year. Half-way between these two points the tangent of the orbit is parallel to the direction of the ray of light, and consequently there is no aberration. When the star is not situated in the ecliptic, it will suffer a displacement in latitude as well as in longitude. To render this still more
28. sensible, let EEE (fig. 28) be the ecliptic, E the earth, and A the true place of a star situated at any altitude above the ecliptic. In the direction EA take E*a* to represent the velocity of light, *ab* that of the earth, and in a parallel direction, that is, parallel to the tangent to the ecliptic at E; the line E*b* will now be the apparent visual ray, and the star will seem to be situated at B. Suppose the earth to be placed at different points of its orbit; the lines E*a* will be all parallel to each other on account of the infinite distance of the star A; the lines *ab* will vary little in magnitude, because they are very small in comparison of E*a*, but their directions will undergo every possible change, being always parallel to the tangent at E. At the two points of the orbit where the tangent is parallel to EA, the two lines E*a* and *ab* coincide, and consequently there is no aberration. Let us next suppose the star to be situated in the pole of the ecliptic. In this case the visual ray is constantly perpendicular to the direction of the earth's motion, so that the star will always appear at a distance of 20″·3 from its true place, or appear to describe a small circle about the pole of the ecliptic. In all other situations, out of the ecliptic, the star's apparent path will be an ellipse, the major axis of which, parallel to the plane of the ecliptic, is always 40″·6, while the minor axis varies with the latitude.

The cause of the aberration being known, we have two methods of measuring its quantity, or the extent of the apparent oscillations, viz. by calculating the angle of de-
27. viation SAS′ (fig. 27), the tangent of which is to radius as AB to AE, that is, as 1 to 10313; or, by direct observation, when the star is in opposition to the sun. The two methods give exactly the same result, and the dimensions of the ellipse described by any star not situated in the ecliptic, in consequence of the aberration, are found to be the same when computed from theory or determined by direct observation. The motion of translation of the earth, therefore, receives a mathematical demonstration from this agreement; and the phenomenon of the aberration, otherwise unimportant on account of its minuteness, thus becomes one of the most interesting discoveries ever made in astronomy. The fact of the earth's orbital motion is, however, rendered so probable by other phenomena, that it must have been universally admitted, although the direct proof had never been discovered.

Sect. IV.—*Of the Measure of Time. Equation of Time.*

The notion of time, or of succession, is generally said to be acquired from the aspect of natural phenomena; but from whatever source it may be derived, it is certain that time itself can only be measured by comparing it with something of which the senses can take cognizance. If we have a series of events, such as the oscillations of a pendulum, or the flux and reflux of the sea, uniformly succeeding each other, then time may be measured by the number of such events that have been observed. In like manner, if a body move uniformly in a certain direction, time may be measured by the spaces over which it successively passes. In strict language, motion and time, being heterogeneous quantities, cannot measure one another; but different times are compared with each other by means of the motions that have taken place in those times respectively; for the motions being supposed uniform, equal spaces are passed over in equal times, or, which is the same thing, the times are directly proportional to the spaces described. If, therefore, we assume for unit the time which is absolved while a certain uniform motion takes place, we may obtain, by a simple proportion, the corresponding time of any other similar motion. In this manner we find the ratio of one portion of time to another, although we can form no idea whatever of its absolute quantity.

In order that motion may be employed as a measure of time, it is indispensably requisite that it be perfectly uniform. The only motions having this property, with which we are acquainted, are those of the rotation of the celestial bodies about their own axes. The motion of the sun and planets in their orbits is irregular from various causes: even the successive returns of the fixed stars to the meridian are rendered unequal on account of the precession and nutation; but the diurnal rotation of the earth appears to be affected by no cause of irregularity whatever. Time, therefore, may be properly measured by this uniform motion; and the method of proceeding is as follows. The culmination of a star, or of a given point of the equator, marks the instant at which the day commences, and at any other instant its horary angle determines the portion of the day which has elapsed at the moment of the observation. In order, therefore, to determine the time of an observation, we must find the horary angle formed by the meridian of the observed star with that which passes through the given point where the motion is supposed to begin; in other words, it is necessary to determine the star's right ascension. This, however, when attempted by direct measurement, is a determination attended with difficulty, and liable to considerable uncertainty. Happily the invention of the pendulum has rendered it unnecessary; and astronomers, instead of deducing the time from the right ascensions, determine, on the contrary, the right ascensions by means of the time indicated by the clock. The clock, of which the motion is supposed to be perfectly regular, is adjusted in such a

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manner that its index describes 24 hours, while a point of the equator describes an arc of 360°, or makes a complete revolution. This is called a *sidereal day*. The sidereal hour is divided in the usual manner into minutes, seconds, &c.; whence the corresponding arcs are easily found at the rate of 15° to an hour. The point whose culmination marks the origin of time is arbitrary; but astronomers have agreed to choose for that purpose the equinoctial point of Aries, from which the right ascensions are reckoned, so that the hours of the clock and the degrees of the equator may commence at the same instant. This point, it is true, is not, and cannot be, permanently marked by any star; but the right ascension in time of any star whatever being the hour of its transit over the meridian, the star will be in the plane of the meridian at the instant denoted by its right ascension in time. On this account sidereal time expresses the actual right ascension of the zenith; or, as it is frequently termed, *the right ascension of the mid-heaven.*

We have already seen, that on account of the precession of the equinoxes, a star employs somewhat more time than the first point of Aries in returning to the meridian. It is therefore not without some violation of language that the interval between two successive transits of a given point of the equator over the meridian is called a *sidereal* day, which, in its strict acceptation, denotes the time which elapses between two successive transits of the same star; but in this case the difference is so small as to be totally inappreciable. The annual precession in longitude is $= 50''\cdot1$, and that in right ascension is nearly the same, excepting in regard to the circumpolar stars, which, therefore, are not employed in regulating the clocks. This arc of $50''\cdot1$, converted into time, gives 3·3 seconds as the time in which a star will pass the meridian later than the equinoctial point, at the end of the year; and this small quantity being distributed over the whole year, is altogether insensible in short intervals of two or three days. The successive transits of a star, therefore, if we abstract from the nutation and aberration, will mark the sidereal day within the hundredth part of a second of time; and the sidereal year, though not immediately ascertainable by observation, becomes a quantity which may be easily computed. But the regularity of the motion of the stars is deranged by the effects of aberration and nutation; so that in order to measure time with the precision required by modern observers, it is necessary to be acquainted with the minute displacements of the stars. If they seem to return to the meridian after equal portions of absolute time, it is only because our organs are unable to distinguish the hundredths of a second.

The sidereal day is a measure of time which, on account of its uniformity and the facility of observing it, is excellently well adapted for astronomical purposes; but relatively to the ordinary wants of life it is not sufficiently marked;—the culmination of the stars is an event entirely unconnected with civil occupations, and which, for any given star, is even invisible during a great part of the year. The proper motion of the sun causes the sidereal day to commence sometimes by day and sometimes by night, so that great confusion and embarrassment would arise from regulating time and civil affairs by the motions of the stars. On this account the diurnal revolution of the sun has been universally adopted as the measure of time. This is called the *civil day*, and denotes the interval of time which elapses between two successive transits of the sun over the same hour-circle. Most nations have agreed in reckoning it from the inferior semicircle of the meridian, so that the civil day commences and terminates at midnight; but astronomers, in imitation of Hipparchus and Ptolemy, usually reckon the commencement of the day from the instant of the sun's culmination, that is, from noon; and count through the 24 hours from one noon to the following. Thus 9 o'clock in the morning of February 14th is by astronomers called February the 13th at 21 hours. The day thus determined is called the *astronomical* or *solar day;* and being regulated by the true motion of the sun, the time which is measured by it is called *true* or *apparent* time.

Astronomical or solar days are not equal. Two causes, in particular, conspire to produce their inequality, namely, the unequal velocity of the sun in his orbit, and the obliquity of the ecliptic. The effect of the first cause is sufficiently sensible. At the summer solstice, when the sun's motion is slowest, the astronomical day approaches nearer the sidereal than at the winter solstice, when his motion is most rapid.

Days in length.

To conceive the effect of the second cause, it is necessary to have regard to the motion of the sun in reference to the equator. The sun describes every day a small arc of the ecliptic. Through the extremities of this arc suppose two meridians to pass; the arc of the equator, which they intercept, is the sun's motion for that day referred to the equator, and the time which that arc takes to pass the meridian is equal to the excess of the astronomical day above the sidereal. But it is obvious that at the equinoxes the arc of the equator is smaller than the corresponding arc of the ecliptic, in the proportion of the cosine of the obliquity of the ecliptic to radius: at the solstices, on the contrary, it is greater in the proportion of radius to the cosine of the same obliquity. The astronomical day is diminished in the first case, and lengthened in the second.

Mean astronomical day.

To have a mean astronomical day independent of these causes of inequality, astronomers have supposed a second sun to move uniformly on the ecliptic, and to pass over the extremities of the axis of the sun's orbit at the same instant with the real sun. This removes the inequality arising from the inequality of the sun's motion. To remove the inequality arising from the obliquity of the ecliptic, conceive a third sun to pass through the equinoxes at the same instant with the second sun, and to move along the equator in such a manner that the angular distances of the two suns at the vernal equinox shall be always equal. The interval between two consecutive returns of this third sun to the meridian forms the *mean astronomical day. Mean time* is measured by the number of the returns of this third sun to the meridian; and *true time* is measured by the number of returns of the real sun to the meridian. The arc of the equator, intercepted between two meridian circles drawn through the centres of the true sun and the imaginary third sun, when reduced to time, is what is called the *Equation of Time.* This will be rendered plainer by the following diagram.

Let Z♈z♎ (fig. 29) be the earth; ZFR*z* its axis; *abcde*, &c. the equator; ABCDE, &c. the northern half of the ecliptic from ♈ to ♎, on the side of the globe next the eye; and MNOP, &c. the southern half on the opposite side from ♎ to ♈. Let the points at A, B, C, D, E, F, &c. mark off equal portions of the ecliptic, gone through in equal times by the real sun, and those at *a, b, c, d, e, f*, &c. equal portions of the equator described in equal times by the fictitious sun; and let Z♈*z* be the meridian. Fig. 2

As the real sun moves obliquely in the ecliptic, and the fictitious sun directly in the equator, any point between ♈ and F on the ecliptic must be nearer the meridian Z ♈ *z*, than the corresponding point on the equator from ♈ to *f*, that is to say, than the point whose distance from ♈ is expressed by the same number of degrees; and the

more so, as the obliquity is greater; and therefore the true sun comes sooner to the meridian every day whilst he is in the quadrant ♈F, than the fictitious sun does in the quadrant ♈ *f*; for which reason the solar noon precedes noon by the clock, until the real sun comes to F, and the fictitious to *f*: which two points being equidistant from the meridian, both suns will come to it precisely at noon by the clock.

Whilst the real sun describes the second quadrant of the ecliptic FGHIKL from Cancer to ♎, he comes later to the meridian every day than the fictitious sun moving through the second quadrant of the equator from *f* to ♎; for the points at G, H, I, K, L, being farther from the meridian, their corresponding points at *g*, *h*, *i*, *k*, *l*, must come to it later; and as both suns come at the same moment to the point W, they come to the meridian at the moment of noon by the clock.

In departing from Libra through the third quadrant, the real sun going through MNOPQ towards ♑ at R, and the fictitious sun through *mnopq* towards *r*, the former comes to the meridian every day sooner than the latter, until the real sun comes to R, and the fictitious to *r*, and then they come both to the meridian at the same time.

Lastly, as the real sun moves equably through STUVW, from R towards ♈, and the fictitious sun through *stuvw*, from *r* towards ♈, the former comes later every day to the meridian than the latter, until they both arrive at the point ♈, and then they make it noon at the same time with the clock.

Having explained one cause of the difference between true and mean time, we now proceed to explain the other cause of this difference, namely, the inequality of the sun's apparent motion, which is slowest in summer, when the sun is farthest from the earth, and swiftest in winter, when he is nearest to it.

If the sun's motion were equable in the ecliptic, the whole difference between the equal time as shown by the clock, and the unequal time as shown by the sun, would arise from the obliquity of the ecliptic. But the sun's motion sometimes exceeds a degree in 24 hours, though generally it is less; and when his motion is slowest, any particular meridian will revolve sooner to him than when his motion is quickest; for it will overtake him in less time when he advances a less space than when he moves through a larger.

Now, if there were two suns moving in the plane of the ecliptic, so as to go round it in a year, the one describing an equal arc every 24 hours, and the other describing in the same time sometimes a less arc, and at other times a larger, gaining at one time of the year what it lost at the opposite; it is evident that one of these suns would come sooner or later to the meridian than the other, as it happened to be behind or before the other; and when they were in conjunction, they would both come to the meridian at the same moment.

As the real sun moves unequably in the ecliptic, let us suppose a fictitious sun to move equably in a circle coincident with the plane of the ecliptic. Let ABCD (fig. 30) be the ecliptic or orbit in which the real sun moves, and the dotted circle *abcd* the imaginary orbit of the fictitious sun; each going round in a year according to the order of letters, or from west to east. Let HIKL be the earth turning round its axis in the same direction every 24 hours; and suppose the two suns to start from A and *a*, at the same moment, A and *a* being in the same straight line, and in the plane of the meridian EH. Suppose also that the real sun, when at A, is at his greatest distance from the earth, where his motion is slowest. In the time that the meridian revolves from H to H again, according to the order of the letters HIKL, the real sun has moved from A to F; and the fictitious sun with a quicker motion from *a* to *f*, through a larger arc: therefore the meridian EH will revolve sooner from H to *h* under the real sun at F, than from HE to *k* under the fictitious sun at *f*; and consequently it will then be noon by the sun-dial sooner than by the clock.

30.

As the real sun moves from A towards C, the velocity of his motion increases all the way to C, where it is at its maximum. But notwithstanding this, the fictitious sun gains so much upon the real, soon after his departing from A, that the increasing velocity of the real sun does not bring him up with the equally-moving fictitious sun till the former comes to C and the latter to *c*, when each has gone half round its respective orbit; and then being in conjunction, the meridian EH, revolving to EK, comes to both suns at the same time, and therefore it is noon by them both at the same moment.

But the increased velocity of the real sun now being at its maximum, carries him before the fictitious one; and therefore the same meridian will come to the fictitious sun sooner than to the real; for whilst the fictitious sun moves from *c* to *g*, the real sun moves through a greater arc from C to G; consequently the point K has its noon by the clock when it comes to *k*, but not its noon by the sun till it comes to *l*. And although the velocity of the real sun diminishes all the way from C to A, and the fictitious sun by an equable motion is still coming nearer to the real sun, yet they are not in conjunction till the one comes to A and the other to *a*, and then it is noon by them both at the same moment.

Comparison of mean and sidereal time.

Mean solar time and sidereal time being both uniform, it is easy to compare the one with the other, and assign the number of degrees, minutes, &c. which the sun and a star will respectively describe in a given portion of sidereal or mean solar time. In a mean solar day the sun's right ascension and mean longitude are increased by 59′ 8″·33; consequently 360° 59′ 8″·33 of the equator pass the meridian in 24 mean solar hours. The sidereal time corresponding to this period is 24 hours 3 min. 56·555 sec.; therefore 24 mean solar hours are equal to 24 hours 3 min. 56·555 sec. of sidereal time; and 24 hours of sidereal time are equal to 23 hours 56 min. 4·0907 sec. of mean solar time, or to 24 hours minus 3 min. 55·9093 sec. This difference of 3 min. 55·9093 sec. is called the *acceleration of the fixed stars* in mean solar time; and the preceding excess of 3 min. 56·555 sec. is the retardation of the sun in sidereal time. Hence the one species of time may be easily converted into the other; and the arc of the equator passed over by the meridian in a given mean time may be calculated. Thus,

$$\frac{360^\circ\ 59'\ 8''{\cdot}33}{24} = 15^\circ\ 2'\ 27''{\cdot}84708$$

is the arc described by a star in one hour of mean solar time.

But the process of converting sidereal or mean solar time into true or apparent time, or of computing from the instants of apparent time the corresponding mean solar and sidereal times, is attended with much greater difficulty. The reason is, that the interval between two successive transits of the sun over the meridian, which, in apparent time, measures the day, is a variable quantity; and hence there cannot exist any constant ratio between true and mean time, as there does between mean and sidereal time. The correction or equation by which apparent time is reduced to mean time, is technically called the *Equation of Time*, and is composed of the aggregate of the several variable terms which denote the inequalities of the sun's motion in longitude. Besides the eccentricity,

the obliquity of the ecliptic, and the variations of that obliquity occasioned by the nutation of the earth's axis, it is affected also by the small alterations of the sun's right ascension, which result from the effect of the planetary perturbations on the earth; and hence the equation of time cannot be exactly computed without the aid of Physical Astronomy.

It will be evident, from what has preceded, that the equation of time expresses merely *the difference between the true and mean right ascensions of the sun*, reduced to time. Its different parts may be calculated numerically in the following manner. Let NA (fig. 31) represent the mean motion of the sun during a given interval, then NA is the sun's mean longitude, N being the first point of Aries. Let NA = M, and from this mean longitude subtract the longitude of the apogee, the remainder will be the sun's mean anomaly. From the mean anomaly let the equation of the centre be found and denoted by E. Take AB = E, then NB = M + E is the longitude corrected for the eccentricity.

Fig. 31.

Let us next suppose BC to be the small quantity by which the sun's longitude is increased in consequence of the perturbations of the planets, and let BC = P; then NC = M + E + P is the true and exact longitude of the sun. Through C let the arc CD be drawn perpendicular to the equator; the point D will be that point of the equator which passes the meridian at the same time with the sun. Let R = NC — ND = the reduction to the ecliptic; we have then the sun's right ascension = M + E + P — R.

Let NF = NA, and F will be the place which the sun would occupy in the equator at the same instant that he occupies the point A in the ecliptic, if he moved uniformly in the former circle; for NF as well as NA will represent the mean diurnal motion of 59′ 8″·33 multiplied by the number of days elapsed in the interval between the equinox N and the time of the observation. The mean sun would therefore pass the meridian with the point F, whereas the true sun passes it with the point D; therefore, at the instant of true noon, when the sun C and the corresponding point D are on the meridian, the mean sun is at a distance from D expressed by the arc FD=M+E+P—R—M=E+P—R. Now, the arc of the equator FD measures the horary angle between the mean and the true sun, or the angle at the pole between the meridian and the hour-circle passing through D; it is therefore converted into time by the following proportion:—

360° : FD :: 24 mean solar hours : time from true noon; consequently the difference between mean and true noon, or the equation of time,

$$= \frac{\text{FD} \times 24^h}{360^\circ} = \tfrac{1}{15}(\text{E} + \text{P} - \text{R}) = d\text{T}.$$

But this equation is not yet perfectly accurate: it requires to be corrected for the effects of nutation. Now it is known that the variation of the mean longitude of the sun, arising from the unequal precession of the equinoxes in consequence of the nutation occasioned by the inclination of the lunar orbit, is expressed by the formula 18″ sin. (360° — moon's node) = 18″ sin. N. This variation, reduced to the direction of the equator, will therefore be 18″ sin. N cos. *e* (*e* being the obliquity of the ecliptic). The difference between the two expressions is 18″ sin. N (1 — cos. *e*) = 36″ sin.^{2} $\frac{1}{2}e$ sin. N = 1″·4887 sin. N, which, reduced to time, becomes 0·09925 sec. × sin. N. This small correction, amounting to less than a tenth of a second, was long omitted in computing the equation of time. When it is included, that equation becomes

$$d\text{T} = \tfrac{4}{60}(\text{E} + \text{P} - \text{R}) + 0{\cdot}09925 \text{ sec.} \times \text{sin. N}.$$

The quantities E, P, R, and N, are to be computed separately from the astronomical tables; and it must be observed, that the result will be expressed in *mean solar time.*

The cosine of the obliquity, that is, cos. 23° 28′, is equal to ·9173 = $\frac{11}{12}$ very nearly. Hence, since the equation of time is equal to the sun's true right ascension, diminished by his mean longitude and the effects of nutation in right ascension (= ND — NA ∓ 18″ sin. N cos. *e*), it may, on denoting the true right ascension by A, be expressed as follows:—

$$d\text{T} = \text{A} - \text{M} \mp 18'' \text{ sin. N} \times \tfrac{11}{12}.$$

This is the form under which the equation of time was expressed by Dr Maskelyne.

The equation of time is at its maximum about the 3d of November, when it amounts to 16′ 16″·7, and is subtractive. At four different times of the year it vanishes, namely, about the 25th of December, the 16th of April, the 16th of June, and the 1st of September. These epochs, however, do not remain constant; for, on account of the change which the line of the apsides is constantly undergoing in reference to the line of the equinoxes, the difference between the true and mean right ascensions of the sun—in other words, the equation of time—varies continually in different years.

Sect. V.—*Of the Spots of the Sun, his Rotation, and Constitution.*

The sun, the great source of light, heat, and animation, when beheld with the naked eye, appears only as a luminous mass of uniform splendour and brightness; but when examined with the telescope, his surface is frequently observed to be mottled over with a number of dark spots, of irregular and ill-defined forms, and constantly varying in appearance, situation, and magnitude. These spots are occasionally of immense size, so as to be even visible without the aid of the telescope; and their number is frequently so great that they occupy a considerable portion of the sun's surface. Dr Herschel observed one in 1779, the diameter of which exceeded 50,000 miles, more than six times the diameter of the earth; and Scheiner affirms that he has seen no less than 50 on the sun's disk at once. Most of them have a deep black nucleus, surrounded by a fainter shade, or *umbra*, of which the inner part, nearest to the nucleus, is brighter than the exterior portion. The boundary between the nucleus and umbra is in general tolerably well defined; and beyond the umbra a stripe of light appears more vivid than the rest of the sun.

The discovery of the sun's spots has been attributed to different astronomers. They appear to have been first taken notice of in a work of Fabricius, the friend of Kepler, which was published at Wittenberg in 1611, under the title of *Joh. Fabricii Phrysii de Maculis in Sole Observatis, et Apparente earum cum Sole Conversione Narratio.* It contains, however, nothing more than a few vague conjectures respecting the spots, the phenomena of which he could not have observed with any degree of accuracy, inasmuch as he seems to have been unacquainted with any method of protecting the eye by intercepting a portion of the solar rays; for he recommends to those who should repeat his observations, to admit into the telescope only a small portion of the sun at once, till the eye should by degrees become able to support the full blaze of light. About the same time the discovery was warmly disputed by the illustrious Galileo, and Scheiner, a German Jesuit, professor of mathematics at Ingolstadt. The whole circumstances connected with this dispute are narrated at great length by Galileo in his work entitled *Istoria e Di-*

mostrazioni intorno alle Macchie Solari, e loro Accidenti, from which it appears certain that he observed the spots so early as April 1611. In a letter published by him in 1612, he remarks that the spots are situated on the surface of the sun, or that at least their distance from it is imperceptible; that the time of their continuance varies from 2 or 3 to 30 or 40 days; that their figures are irregular and variable; that some are seen to separate, and others to unite, even on the middle of the disk; that besides these peculiar motions, they have also a common motion, in virtue of which they traverse the disk in parallel lines. From this general motion he infers that the sun turns on an axis from west to east; and he adds as a curious remark, that the spots are confined within a zone extending only about 28 or 29 degrees to the north and south of the sun's equator. Galileo illustrates all these positions by mathematical reasoning, and by drawings of the spots made on many successive days.

Scheiner's observations were first announced in January 1612, in three letters addressed to his friend Marc Velser, a magistrate of Augsburg. In the first of these, the date of which is November 1611, he says that he had observed the spots seven months before, but that, having a different object in view, he had given little attention to them. He observed them again in the following October, and at that time imagined the appearance was owing to some imperfection of his telescope, till he was convinced by repeated observations that it was necessary to refer it to the sun. From these remarks it is pretty clear that Scheiner had formed no accurate notions respecting the spots before October 1611, that is, six months after they had been observed by Galileo. Scheiner made the observation of the solar spots his whole occupation during the following eighteen years, in the course of which he discovered the position of the solar equator, and formed a theory much more complete than that of Galileo. The account of his observations was published in 1630, under the title of *Rosa Ursina, sive Sol ex admirando Facularum et Macularum suarum Phænomeno Varius*, &c.

The discovery of the solar spots has also been claimed for our countryman Harriot. Amidst these conflicting pretensions it is perhaps impossible to arrive at the truth; but the matter is of little importance; the discovery is one which followed inevitably that of the telescope, and an accidental priority of observation can hardly be considered as establishing any claim to merit.

The solar spots furnish an extensive subject of curious speculation, but in an astronomical point of view they are chiefly interesting on account of their establishing the fact, and affording the means of determining the period, of the rotation of the sun. In order to obtain a precise idea of the position of a spot, and the path which it describes, it is necessary to project that path on the plane passing through the centre of the sun, and perpendicular to the visual ray drawn from the earth to the sun's centre. Fig. 32. Suppose the diameter of a circle ASB (fig. 32) to be divided into as many parts of unity as there are seconds in the apparent diameter of the sun. Let CP be taken equal to the number of seconds contained in the difference of the longitudes of the spot and the sun's centre, and the perpendicular PM equal to the number of seconds in the latitude of the spot; then M will represent its position on the surface of the sun. By repeating the same operation a number of days consecutively, a series of points M M′ M″, &c. will be obtained in the apparent path of the spot on the sun's disk, or rather in the projection of that path on the plane perpendicular to the visual ray. This projection is in general an oval slightly differing from an ellipse; and it is found that all the spots observed at the same time describe similar and parallel curves. They also return to the same relative positions in the same time, and their period is about $27\frac{1}{3}$ days.

The paths described by the spots undergo very considerable changes, according to the season of the year at which they are observed. About the end of November and beginning of December they appear simply as straight lines M*m*, M′*m*′, M″*m*″ (fig. 33), along which the Fig. 33. spots move in the direction M*m*, that is, they enter on the eastern and disappear on the western edge of the sun's disk; and the points at which they disappear are more elevated, or nearer the north pole of the ecliptic, than those at which they enter. After a certain time the lines M*m* begin to assume a curved appearance, and form ovals, as represented in fig. 34. During the winter and spring Fig. 34. the convexity of the ovals is turned towards the north pole of the ecliptic; but their inclination, or rather the inclination of the straight lines joining their extreme points, to the plane of the ecliptic continues to diminish, and about the beginning of March disappears; so that the points at which they seem to enter and leave the sun's disk are equally elevated, as in fig. 35. From this Fig. 35. time the curvature of the ovals diminishes; they become narrower and narrower till about the end of May or beginning of June, when they again appear under the form of straight lines (fig. 36); but their inclinations to the Fig. 36. ecliptic are now precisely in a contrary direction to what they were six months before. After this they begin again Plate to expand, as in fig. 37, and their convexity is now turned LXXXII. towards the south pole. Their inclinations also vary at Fig. 37. the same time, and about the commencement of September they are seen as represented in fig. 38; the points Fig. 38. at which they enter and disappear being again equally elevated. After this period the ovals begin to contract and become inclined to the ecliptic, and by the beginning of December they have exactly the same direction and inclination as they had the previous year.

These phenomena are renewed every year in the same order, and the same phases are always exhibited at corresponding seasons. Hence it is evident that they depend on a uniform and regular cause, which is common to all of them, since the orbits described by the various spots are exactly parallel, and subject in all respects to the same variations. The simplest method of explaining the phenomena is to suppose with Galileo that the spots are adherent to the surface of the sun, and that the sun uniformly revolves round an axis inclined to the axis of the ecliptic. If the axis of revolution were perpendicular to the plane of the ecliptic, the spots, supposing them to adhere to the sun's surface, would describe circles parallel to that plane, which, seen from the earth, would appear as so many parallel straight lines; but by supposing the axis to have a suitable inclination, all the phenomena become explicable in a very simple manner. While the sun is carried round in his orbit, his axis, constantly preserving its parallelism, will successively assume different positions relatively to the earth; and the planes of the circles described by the spots, which planes are always perpendicular to the axis, will consequently be presented to us under different inclinations; hence the variations of their apparent curvature. In two opposite points of the orbit the visual ray drawn from the earth to the centre of the sun is perpendicular to the axis of rotation. In these two positions the poles of the sun, or the points in which the axis meets the surface, are both visible at the same moment, and the spots appear to move in parallel straight lines. But as the axis retains this perpendicular position only for an instant, and declines from it very sensibly while the spot traverses the sun's disk, the path of

the spots over the entire disk is neither a straight line nor an ellipse, one of which it would necessarily be if the sun, while revolving about his axis, did not change his place in his orbit. When the axis is not perpendicular to the visual ray, the path of the spots will appear to be a curve of which the concavity is turned towards that pole which is visible from the earth. This inclination of the solar axis to the plane of the ecliptic also explains the reason why the points of the disk at which the spots appear are more elevated during one half of the year, and more depressed during the other half, than those at which they disappear. It will also follow from the same hypothesis, that the curvature of the ovals must be the greatest possible when the straight lines joining their extremities are parallel to the ecliptic; and, on the contrary, least when the same straight lines are most inclined to the ecliptic; all which is exactly conformable to observation.

The various appearances which we have now described may be accurately represented by means of a common celestial or terrestrial globe. Let the wooden horizon of the globe, which is here supposed to represent the sun, be placed horizontally in the same plane with the eye of the spectator, and the pole be inclined about 7° from the zenith. The wooden horizon will now represent the ecliptic; and if the spectator walk round the globe, always keeping his eye in the plane of the wooden horizon, the circles of latitude will appear to him as ellipses of different inclinations and eccentricities: in two opposite points they will appear as straight lines, and, in short, exhibit in their various positions all the phenomena of the oval paths described by the spots of the sun.

The consequences deduced from the hypothesis of the rotatory motion of the sun are so perfectly conformable with observation, as to render the inference inevitable, that *the sun revolves from west to east, on an axis inclined about* 93° *to the plane of the ecliptic.* The plane which passes through the centre of the sun, perpendicular to the axis of rotation, is the *Equator* of the sun; the straight line joining the points in which it intersects the ecliptic is called the *Line of the Nodes* of the equator. The *Nodes* themselves are the two opposite points in which this straight line, produced indefinitely, meets the celestial sphere.

In order to determine the situation of the solar axis in space, it is necessary to find its inclination to the ecliptic, and the angle which the line of the nodes makes with any given line on the plane of the ecliptic, for example, with the line of the equinoxes. The requisite data for the solution of this problem are three different positions of the same spot, which must be obtained by observation.

Fig. 39. Let S (fig. 39) be the centre of the sun's disk, AB a parallel to the terrestrial equator, and M the place of a spot, the co-ordinates of which, as referred to AB, are SX and MX. In this figure the earth is supposed to be situated in a straight line passing through S perpendicular to the plane of the paper, and it is to be recollected that SX and MX are in fact arcs of the solar globe, though so small when seen from the earth that they may be regarded as straight lines. By comparing the times of the transits of B, the border of the disk, and the spot M, we shall find BX, from which, as SB the semidiameter of the sun is known, we shall have SX the difference of the right ascensions of the spot and sun's centre. The line CY, which is the difference of the declination of the border of the disk and that of the spot, is measured by the micrometer. This will give MX the declination of the spot. Now, tan. MSX $= \frac{\text{MX}}{\text{SX}}$, and SM $= \frac{\text{SX}}{\text{cos. MSX}}$; therefore SM is also a known quantity. Let EE be the ecliptic, e = obliquity of the ecliptic, and $\odot$ = the longitude of the sun. The angle BSE, which is technically called the *Angle of Position*, is the complement of the angle made by the ecliptic with the circle of declination passing through the sun, and is therefore given by the formula tan. BSE = tan. e cos. $\odot$: hence MSE (=MSX — BSE) is also given. On SE let fall the perpendicular Mm, then Mm = SM sin. MSE is the geocentric latitude of the spot, and Sm = SM cos. MSE is the difference between its geocentric longitude and that of the centre of the sun: the object is now to determine the angles subtended by these lines at the centre of the sun, that is, to convert the *geocentric* into *heliocentric* latitudes and longitudes.

Suppose two straight lines to be drawn from the earth, one to the centre of the sun, and the other to the centre of the spot M, and let θ be their inclination, which is measured by SM, and is consequently known, being the geocentric distance of the spot from S, the centre of the sun's disk. Let R = distance of the sun's centre from the earth, r = semidiameter of the sun, φ = the angle made at the centre of the sun by the straight lines drawn from it to the earth and the spot M, and let ψ be the remaining angle of the triangle formed by the lines joining the earth, the centre of the sun, and the spot. We have then $r : \text{R} :: \sin.\theta : \sin.\psi$, whence $\sin.\psi = \frac{\text{R}}{r}\sin.\theta$. But R : r as radius to the sine of half the sun's true diameter; therefore $\sin.\psi = \frac{\sin.\theta}{\sin.\frac{1}{2}\text{ sun's diameter}}$. Now $\varphi = 180° - \psi - \theta$, consequently we have the number of degrees, minutes, and seconds in φ, the heliocentric distance of the spot from the straight line which joins the centres of the earth and sun. Having thus obtained the hypothenuse SM in parts of a great circle of the solar orb, the sides Sm and Mm will be obtained in similar parts from the common trigonometrical formulæ for the resolution of a right-angled spherial triangle. These formulæ give

$$\text{tan. S}m = \text{tan. SM cos. MSE},$$
$$\text{sin. M}m = \text{sin. SM sin. MSE}.$$

It will be remarked that Mm is the heliocentric latitude of the spot, Sm the difference of its longitude and that of the earth; and as the longitude of the earth is equal to 180° + that of the sun, the heliocentric longitude of the spot will be 180° + $\odot$ — SM if the spot is behind or to the east of the centre of the sun, and 180° + $\odot$ + Sm if it precedes the centre.

In this manner the heliocentric longitudes and latitudes of the spots are deduced from their observed right ascensions and declinations. The next step is to show how they are employed in determining the position of the solar axis. This problem is in practice somewhat laborious, although the principles on which its solution rests are sufficiently simple. The planes of the circles described by the spots are parallel to the sun's equator: if, therefore, the position of one of them can be found, the position of the equator, and consequently of the axis, will be found at the same time. Now, the position of a plane is determined by three given points through which it is required to pass; consequently, by three observations of the same spot, we shall have three points in its plane, and thence the plane itself. The problem is therefore one of pure geometry, and may be solved in various ways. The results of the most accurate observations make the inclination of the solar equator to the ecliptic amount to 7° 19′ 23″ or, 7°$\frac{1}{3}$ very nearly; and the heliocentric longitude of the ascending node, that is, the point in which the equator of the sun intersects the ecliptic, in passing from

south to north, 80° 7′ 4″. The position of the node seems to undergo no variation, except such as may be supposed to arise from the precession of the equinoxes.

It has already been mentioned that the mean time in which a solar spot returns to the same position, relatively to the earth, is 27·3 days. This, however, is not the time in which the sun makes a revolution about his axis. In the interval of 27·3 days the sun describes in the ecliptic an arc equal to 26°·91 (for $365^d{\cdot}25 : 27^d{\cdot}3 :: 360° : 26°{\cdot}91$), and by virtue of this motion alone he exhibits every day different points of his surface, the whole of which would be successively shown to the earth in the course of a year, independently of the motion of rotation. Hence results an apparent annual rotation round an axis perpendicular to the ecliptic, and we must abstract the effects of this optical illusion in order to arrive at the time of a real rotation. This apparent rotatory motion will be easily understood by referring to fig. 40, in which S is the sun, E the earth, and C the point in which the visual ray ES intersects the surface of the sun. Suppose the sun to have advanced in his orbit from S to S′, the visual ray drawn from the sun's centre to the earth will now meet the surface in a different point C′, and the angular distance between C and C′ will be found by drawing S′E′ parallel to SE; for the point *c* in which S′E meets the surface will correspond to C, and the arc C′*c*, or the angle E′S′E, will be the apparent rotation, while the sun advances in his orbit from S to S′. Now, the angle E′S′E is equal to S′ES, or the apparent rotatory motion is equal to the angular motion of the sun in his orbit; hence, since the real rotation is in a contrary direction, it is obvious that, if the axis were perpendicular to the plane of the ecliptic, when a spot appears to have made one revolution, it has in reality passed over an arc equal to 360° + 26°·91, or 386·91 degrees. By a simple proportion, therefore,

Fig. 40.

$$386{\cdot}91 : 360 :: 27{\cdot}3 : 25{\cdot}4;$$

and consequently 25·4 days is the real time of the sun's revolution. This result is, however, not quite accurate, on account of its having been supposed that the axis of rotation is perpendicular to the ecliptic, whereas it differs from a perpendicular to that plane by $7°\frac{1}{3}$; but the correction necessary on account of the difference is so small as to fall far within the limits of the errors to which the observations are liable; it is therefore unnecessary to have regard to it.

Observations liable to uncertainty.

Observations of the spots, from which the elements of the sun's rotation are deduced, are attended with a very considerable degree of uncertainty. The semidiameter of the sun, which at the surface of the earth subtends an angle of only 16′, or 960″, is equivalent to 90° at the centre of the sun. Hence the error of a single second (and it is impossible to answer for one or two seconds in observations of this sort) corresponds to about 338″, or 5′ 38″, on the surface of the solar globe. An observer may, therefore, notwithstanding the greatest care, be mistaken to the extent of 10′ with regard to the length of a heliocentric arc; and when to this we add, that the margins of the spots are ill defined, and even changeable, so that their centres, which it becomes necessary to observe, are not always the same, it will not appear surprising that a considerable discordance exists among the results of different observations. The uncertainty respecting the time of rotation amounts to no less than 10 or 12 hours. From a careful discussion of a numerous set of observations, Delambre found the time of rotation to be only 25·01154 days, instead of 25·4 given above; and he remarks that, in order to render the last-mentioned number admissible, it is necessary to suppose either an error of 2° 22′, which is scarcely possible, or else that the spot has a proper motion in the same direction as the motion of rotation of the earth and all the planets.

From four different combinations of equations, derived from eleven observations of the same spot, Delambre computed the following table of the elements of rotation.

	Node.	Inclination.	Revolution.	Synodic Revol.
1	80° 45′ 7″	7° 19′ 17″	25^d 0^h 17^m	26^d 4^h 17^m
2	79 21 35	7 12 37		
3	80 33 40	7 16 33		
4	79 47 55	7 29 4		
	80 7 4	7 19 23	Diurnal motion 14°·394	

With regard to observations on the sun's spots, Delambre remarks that he attaches little value to them, first, because it is impossible to make them well; and, secondly, because, even if they were sure, they only lead to results of little importance to astronomy. He discussed a hundred different spots, each observed at least three times by Messier, and deduced thirty different determinations of the elements of rotation. The more he multiplied his calculations, the more certain he became of the impossibility of a good solution; of which, indeed, there is no other chance than in a compensation of errors, little probable on account of their enormous magnitudes. These discrepancies render it probable that the spots, besides partaking of the general motion of the solar globe, have also proper motions either of displacement, or occasioned by a change of form, which may long prevent this part of astronomy from reaching a greater degree of exactness than it has already attained.

From the circumstance that the sun is incontestably endowed with a rotatory motion, Lalande concluded that, according to the rules of probability, he ought also to have a motion of translation in space. This idea was adopted by Herschel, and is now generally received as probable. It explains some, though not all, of the proper motions which have been supposed to be observed among the stars. If, indeed, the stars are so many suns, revolving like ours each on its own axis of rotation, it is extremely probable that they have also motions of translation; and thus, there being no fixed points in the heavens, the problem of their proper motions becomes so complicated as to be altogether insoluble.

The only interesting fact which has been deduced from the observations of the solar spots is the rotation of the sun. The curious appearances which they exhibit have, however, attracted great attention, and given rise to numerous theories respecting the constitution of that immense body which governs and vivifies the planetary system. We will now proceed to give a brief account of the appearances, and mention some of the theories that have been founded on them; premising, that after all that has been written on this subject, we are not yet, and probably never will be, in possession of any definite knowledge. The nature of the spots, and the physical constitution of the sun, afford fruitful subjects of harmless conjecture and speculation, but form no part of science.

Appearances of the spots.

The phenomena of the solar spots, as delivered by Scheiner and Hevelius, may be summed up in the following particulars. 1. Every spot which has a nucleus, or comparatively dark part, has also an umbra, or fainter shade surrounding it. 2. The boundary between the nucleus and umbra is always distinct and well defined. 3. The increase of a spot is gradual, the breadth of the nucleus and umbra dilating at the same time. 4. In like manner the decrease of a spot is gradual, the breadth of the nucleus and umbra contracting at the same time.

5. The exterior boundary of the umbra never consists of sharp angles, but is always curvilinear, how irregular soever the outline of the nucleus may be. 6. The nucleus of a spot, whilst on the decrease, often changes its figure by the umbra encroaching irregularly upon it, insomuch that in a small space of time new encroachments are discernible, whereby the boundary between the nucleus and umbra is perpetually varying. 7. It often happens, by these encroachments, that the nucleus of a spot is divided into two or more nuclei. 8. The nuclei of the spots vanish sooner than the umbra. 9. Small umbræ are often seen without nuclei. 10. An umbra of any considerable size is seldom seen without a nucleus in the middle of it. 11. When a spot which consisted of a nucleus and umbra is about to disappear, if it is not succeeded by a *facula* or spot brighter than the rest of the disk, the place where it was is soon after not distinguishable from the rest.

In the *Philosophical Transactions*, vol. lxiv. Dr Wilson, late professor of astronomy at Glasgow, has given a dissertation on the nature of the solar spots, in which he mentions the following appearances. 1. When the spot is about to disappear on the western edge of the sun's limb, the eastern part of the umbra first contracts, then vanishes, the nucleus and western part of the umbra remaining; then the nucleus gradually contracts and vanishes, while the western part only of the umbra remains. At last this disappears also; and if the spot remains long enough to become again visible, the eastern part of the umbra first becomes visible, then the nucleus; and when the spot approaches the middle of the disk, the nucleus appears environed by the umbra on all sides, as already mentioned. 2. When two spots lie very near to one another, the umbra is deficient on that side which lies next to the other spot: and this will be the case, though a large spot should be contiguous to one much smaller; the umbra of the large spot will be totally wanting on that side next the small one. If there are little spots on each side of the large one, the umbra does not totally vanish, but appears flattened or pressed in towards the nucleus on each side. When the little spots disappear, the umbra of the large one extends itself as usual. This circumstance, he observes, may sometimes prevent the disappearance of the umbra in the manner above mentioned; so that the western umbra may disappear before the nucleus, if a small spot happens to break out on that side.

In the same volume, p. 337, the Rev. Dr Wollaston observes that the appearances mentioned by Dr Wilson are not uniform. He positively affirms that the faculæ or bright spots on the sun are often converted into dark ones. "I have many times," says he, "observed near the eastern limb a bright facula just come on, which has the next day shown itself as a spot, though I do not recollect to have seen such a facula near the western one after a spot's disappearance. Yet, I believe, both these circumstances have been observed by others, and perhaps not only near the limbs. The circumstance of the faculæ being converted into spots, I think I may be sure of. That there is generally, perhaps always, a mottled appearance over the face of the sun, when carefully attended to, I think I may be as certain. It is most visible towards the limbs, but I have undoubtedly seen it in the centre; yet I do not recollect to have observed this appearance, or indeed any spots, towards the poles. Once I saw, with a twelve-inch reflector, a spot burst to pieces while I was looking at it. I could not expect such an event, and therefore cannot be certain of the exact particulars; but the appearance, as it struck me at the time, was like that of a piece of ice when dashed on a frozen pond, which breaks to pieces and slides in various directions." He also observes, that the nuclei of the spots are not always in the middle of the umbræ, and gives the figure of one seen on the 13th of November 1773, which is a remarkable instance to the contrary.

The faculæ, or bright spots, were observed with particular attention by Messier, who frequently saw them enter on the eastern limb of the sun, disappear as they approached the centre of the disk, re-appear on the opposite limb, and continue visible, as they had done at the time of their first appearance, for about three days, till they were carried off the disk by the rotation of the sun. Spots frequently broke out in these faculæ, and when this did not happen, they were succeeded by spots which generally became visible on the following day; and from the regularity of this occurrence, he was enabled to predict the appearance of a spot 24 hours before it entered on the sun's disk. He observed, also, that the magnitude of the spots was proportional to the brightness of the antecedent faculæ. Like the spots, the faculæ are generally confined to the equatorial regions of the sun; but they have been occasionally observed by Schroeter on every part of the disk.

To explain these singular appearances, numerous theories, more or less plausible, have been proposed, but all resting on many gratuitous assumptions, and subject to great difficulties. Scheiner imagined that the spots do not belong to the sun, but supposed them to be inferior planets revolving at no great distance from the central luminary. Galileo, Hevelius, and others, have supposed them to be scoriæ floating in the inflammable liquid matter of which they imagined the sun to be composed. This opinion, although it accounts for the appearance of the spots in the equatorial regions of the sun, to which such scoriæ would be carried by the centrifugal force resulting from his rotation, cannot be reconciled with the regularity with which the spots frequently re-appear on the eastern limb of the sun. Dr Wilson, having observed that the spots situated near the edge of the disk are narrow, and without a penumbra on the side next the centre, and that only the central spots are completely surrounded by a penumbra (appearances which would be exactly represented by a conical gulf or cavity presented to us under different aspects by the revolution of the sun), was led to adopt the opinion, that the appearances of the spots are occasioned by real excavations in the solar globe. He supposed the sun to consist of a dark nucleus, covered only to a certain depth by a luminous matter, not fluid, through which openings are occasionally made by volcanic or other energies, permitting the solid nucleus of the sun to be seen; and that the umbra which surrounds the spot is occasioned by a partial admission of the light upon the shelving sides of the precipice opposite to the observer. It is evident that, in proportion as these excavations are seen obliquely, their apparent dimensions will be diminished; one of the edges will disappear as it approaches the sun's limb, or come more into view as it advances towards the middle of the disk; when the spot is about to leave the disk, the bottom of the excavation, or the nucleus seen through it, will first disappear, but a sort of faint or obscure spot will remain visible as long as the visual ray penetrates the cavity. These appearances are all conformable to the laws of perspective; but Dr Wilson, wishing to give a still more palpable demonstration of the accuracy of his theory, fitted up a large globe, into which holes of the proper dimensions were inserted; and this machine being placed at a distance, and made to revolve, was found, when examined through a telescope, to exhibit in the course of its revolution all the phenomena of the solar spots.

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Dr Wilson's theory was keenly combated by Lalande, who adduced several observations of his own, and some by Cassini, that could not be explained by means of it; and urged with reason, that an hypothesis, founded on the uniformity of appearances which in reality are exceedingly variable, was entitled to little consideration. Lalande himself supposed the spots to be scoriæ which have settled or fixed themselves on the summits of the solar mountains; an opinion which he grounded on this circumstance, that some large spots which had disappeared for several years were observed to form themselves again at the identical points at which they had vanished.

Herschel's observations.

The late Sir William Herschel, with a view to ascertain more accurately the nature of the sun, made frequent observations upon it from the year 1779 to the year 1794. He imagined the dark spots on the sun to be mountains, which, considering the great attraction exerted by the sun upon bodies placed at its surface, and the slow revolution it has upon its axis, he thought might be more than 300 miles high, and yet stand very firmly. He says that in August 1792 he examined the sun with several powers from 90 to 500, when it evidently appeared that the dark spots are the opaque ground or body of the sun, and that the luminous part is an atmosphere, through which, when interrupted or broken, we obtain a view of the sun itself. Hence he concluded that the sun has a very extensive atmosphere, consisting of elastic fluids that are more or less lucid and transparent, and of which the lucid ones furnish us with light. This atmosphere, he thought, cannot be less than 1843, nor more than 2765 miles in height; and he supposed that the density of the luminous solar clouds needs not be much more than that of our aurora borealis, in order to produce the effects with which we are acquainted. The sun, then, if this hypothesis be admitted, is similar to the other globes of the solar system with regard to its solidity, its atmosphere, its surface diversified with mountains and valleys, its rotation on its axis, and the fall of heavy bodies on its surface; it therefore appears to be a very eminent, large, and lucid planet, the primary one in our system, disseminating its light and heat to all the bodies with which it is connected.

Herschel supposed that there are two regions or strata of solar clouds; that the inferior stratum is opaque, and probably not unlike our own atmosphere, while the superior is the repository of light, which it darts forth in vast quantities in all directions. The inferior clouds act as a curtain to screen the body of the sun from the intense brilliancy and heat of the superior regions, and, by reflecting back nearly one half of the rays which they receive from the luminous clouds, contribute also greatly to increase the quantity of light which the latter send forth into space, and thereby perform an important function in the economy of the solar system. The luminous clouds prevent us in general from seeing the solid nucleus of the sun; but in order to account for the spots, he supposes an empyreal elastic gas to be constantly forming at the surface, which, carried upwards by reason of its inferior density, forces its way through the planetary or lower clouds, and mixing itself with the gases which have their residence in the superior stratum, causes decompositions of the luminous matter, and gives rise to those appearances which he describes under the name of *corrugations*. Through the openings made by this accidental removal of the luminous clouds, the solid body of the sun becomes visible, which, not being lucid, gives the appearance of the dark spots or nuclei seen through the telescope. The length of the time during which the spots continue visible renders it evident that the luminous matter of the sun cannot be of a liquid or gaseous nature; for, in either case, the vacuity made by its accidental removal would instantly be filled up, and the uniformity of appearance invariably maintained. Herschel supposed the luminous clouds to be phosphorescent.

Uncertainty respecting the constitution of the sun.

It would be a needless waste of time to enter into any discussion of a theory so entirely vague and fanciful, and so destitute of all solid foundation. Till we are better acquainted with the nature of light, fire, and heat, and have attained to the knowledge of every possible mode in which these elements can be produced and propagated, all hypotheses respecting the construction of the sun can only be gratuitous and conjectural. Some interesting questions, however, arise out of this subject. Whether the inferior stratum of solar clouds is sufficiently dense, as Herschel imagined, to protect the body of the sun from the scorching effects of the surrounding regions of light and heat, and render it a fit habitation for human beings, is a question of no importance to man, or to any thing pertaining to his planet; but it is interesting for him to know whether the light and heat dispensed by the sun are liable to any variation or secular diminution, either connected with the spots, or resulting from a decrease of the sun's volume.

Mass of the sun undergoes no sensible diminution.

Those philosophers who adopt the hypothesis of the production of light and heat by the vibrations of an ethereal fluid, consider the mass of the sun to be invariable. Those, on the contrary, who attribute these effects to an emanation from the sun, think his mass and volume must be diminished by the incessant discharge of torrents of luminous particles from his surface. During the two thousand years which have elapsed since the first astronomical observations, no diminution of the sun's volume has been perceived; but it must be remarked that such an effect may have taken place, though not yet sensible to our instruments. The sun's diameter is nearly 2000″; and at the distance of 95,000,000 miles a second corresponds to 460 miles. Now, supposing the solar diameter to suffer a daily diminution of two feet, which may be considered as enormous, considering the vast magnitude of the sun, and the excessive rarity of light, the diminution would amount to 800 feet in a year, and to 460 miles, or 1″, in 3000 years. Thus, after thirty centuries, the diminution would still be imperceptible, inasmuch as our instruments are not sufficiently accurate to enable us to appreciate, in an observation of this sort, so small a variation as one second.

Connection of the solar spots with the temperature of the seasons.

Some astronomers, after Herschel, have imagined that the existence of the solar spots has an influence on the temperature of the seasons. In 1823 the summer was cold and wet; the thermometer at Paris rose only to 23°·7 of Reaumur, and the sun exhibited no spots; whereas in the summer of 1807 the heat was excessive, and the spots of vast magnitude. The relation, however, between the temperature and the appearance of the solar spots is not so uniform as to give much weight to this opinion. Warm summers, and winters of excessive rigour, have happened in the presence or absence of the spots. The year 1783 was remarkable for its fertility and the magnitude of the solar spots; a dry fog enveloped the greater part of Europe, and was followed by the earthquake of Calabria. Another opinion entertained by Herschel was, that one hemisphere of the sun emits less light than the other, so that when viewed at a great distance he will resemble some stars of which the brilliancy is subject to periodical variations.

Sun supposed to have an atmosphere.

By reason of the globular figure of the sun, his surface towards the border of the disk is seen obliquely, and therefore a much greater portion of it is comprehend-

ed under a given visual angle, than when the ray proceeds from his centre. Now, as every point of the sun's surface is supposed to emit an equal quantity of light in all directions, it follows that the light ought to be much more intense near the circumference of the disk, because a greater number of rays will proceed from the larger surface, which forms the oblique base of the luminous cone. Bouguer, deceived by some imperfect experiments, thought the light more intense at the centre of the disk than towards the limb; a circumstance which could only be explained by supposing the light to be diminished by some cause which acts most powerfully with regard to the borders of the disk. Such would be the effect of a dense atmosphere surrounding the sun; for in this case the rays which proceed from the border must traverse a much greater extent of the solar atmosphere, and consequently be absorbed in greater proportion than those which proceed from the central parts and traverse it directly; just as the atmosphere of the earth renders the light of the stars at the horizon much feebler than at the zenith. It has been found, however, that Bouguer's experiments were inaccurate, and that the light is equally intense at the border and the centre. The existence of a solar atmosphere cannot therefore be demonstrated in this manner; but it is clearly indicated by the faint light which is observable round the sun's limb during a total eclipse.

Zodiacal light.

Another very curious phenomenon connected with the sun, is the faint nebulous aurora which accompanies him, known by the name of the *Zodiacal Light*. This phenomenon was first observed by Kepler, who described its appearance with sufficient accuracy, and supposed it to be the atmosphere of the sun. Dominic Cassini, however, to whom its discovery has been generally but erroneously attributed, was the first who observed it attentively, and gave it the name which it now bears. It is visible immediately before sunrise, or after sunset, in the place where the sun is about to appear, or has just quitted, in the horizon. In total eclipses it is seen surrounding the sun's disk, and resembling the beard of a comet. It has a flat lenticular form, and is placed obliquely on the horizon, as represented in fig. 41, the apex extending to a great distance in the heavens. Its direction is always in the plane of the sun's equator, and for this reason it is scarcely visible in our latitudes, excepting at particular seasons, when that plane is nearly perpendicular to the horizon. When its inclination is great, it is either concealed altogether under the horizon, or at least rises so little above it, that its splendour is effaced by the atmosphere of the earth. The most favourable time for observing it is about the beginning of March, or towards the vernal equinox. The line of the equinoxes is then situated in the horizon, and the arc of the ecliptic SS′ S″ (fig. 42) is more elevated than the equator SEQ by an angle of $23\frac{1}{2}$ degrees; so that the solar equator, which is slightly inclined to the ecliptic, approaches nearer to the perpendicular to the horizon, and the pyramid of the zodiacal light is consequently directed to a point nearer the zenith, than at any other season of the year. For example, at the summer solstice, S″T, a tangent to the ecliptic, is parallel to EQ the tangent to the equator, and the luminous pyramid is in a plane less elevated by $23°\frac{1}{2}$ than at the time of the vernal equinox.

Fig. 41.

Fig. 42.

Different opinions regarding the zodiacal light.

Numerous opinions have been entertained respecting the nature and cause of this singular phenomenon. Cassini thought it might be occasioned by the confused light of an innumerable multitude of little planets circulating round the sun, in the same manner as the milky way owes its appearance to the light of agglomerated myriads of stars. Its resemblance to the tails of comets has been noticed by Cassini, Fatio Duillier, and others; and Euler endeavoured to prove that they are both owing to similar causes. Mairan, like Kepler, ascribed it to the atmosphere of the sun; and this hypothesis was generally adopted, till it was shown by Laplace to be untenable for the following reasons. The atmosphere of any planet, endowed with a motion of rotation, cannot extend to an indefinite distance: it can only reach to such a height that the centrifugal force is exactly balanced by the force of gravity. Beyond this height the atmosphere would be dissipated by the superior energy of the centrifugal force. Now the height above the sun at which the two forces are equal is that at which a planet, if placed there, would revolve about the sun in the same time in which the sun performs a revolution on his axis. But the orbit of such a planet would be greatly inferior to the orbit of Mercury; for the time in which Mercury makes a revolution in his orbit is eighty-eight days, while the sun revolves about his axis in twenty-five; it is therefore certain that the atmosphere of the sun cannot extend to the orbit of Mercury. Now, the greatest elongation of Mercury does not exceed 28°, and the zodiacal light has been observed to extend to above 100°, reckoning from the sun to the apex of the luminous pyramid. Hence the phenomenon cannot proceed from the sun's atmosphere. Laplace further remarks, that the ratio of the equatorial and polar axes of the solar atmospherical spheroid cannot exceed that of three to two; whence its form would not correspond with the lenticular appearance of the zodiacal light. But to whatever cause this luminous matter is to be attributed, it is certain that it is of extreme rarity, inasmuch as it does not intercept the light of the smallest stars which are seen through it without any diminution of splendour.

On the subject of the solar spots and zodiacal light the following works may be consulted:—Galileo, *Istoria e Dimostrazioni intorno alle Macchie Solari*, Rome, 1613; Scheiner, *Rosa Ursina*, Bracciani, 1630; Hevelius, *Selenographia*, Gedani, 1647; Reutschius, *De Maculis et Faculis Solaribus*, Wittemb. 1661, 4to; Cassini, *Nouv. Observ. des Taches du Soleil*; Hooke, *Tractatus de Maculis Solaribus, et Lumine Zodiacali, in Oper. Posth.* Lond. 1705; Weidler, *De Coloribus Mac. Sol.* in his *Observ. Meteorol.* 1728–9, Wittemb. 1729; Boscovich, *De Mac. Sol.* Rom. 1736, 4to; De Lisle, *Mémoires pour servir à l'Histoire de l'Astr.* Petersb. 1738; Bernoulli, *Lettres Astronomiques*, 1771; Wilson, *Phil. Trans.* 1774, vol. lxiv.; *Ibid.* 1783; Wollaston, *Phil. Trans.* 1774; Lalande, *Phil. Trans.* 1776, *Mém. Acad.* 1776, and *Astronomie*, tom. iii. p. 277; Herschel, *Phil. Trans.* 1795 and 1801; Woodward *on the Substance of the Sun*, Washington, 1801; Biot, *Traité de l'Astronomie Physique*, tom. ii.; Bohn, *Disput. Astrom. de Fascia Zodiacali*; Cassini, *Mém. Acad. Par.* tom. vii. p. 119, and viii. p. 193; Mairan, *Traité Physique et Historique de l'Aurore Boreale*, 1731; Lalande, *Astronomie*, tom. i. p. 276; Laplace, *Exposition du Système du Monde*; Delambre, *Hist. de l'Astronomie Moderne*, tom. ii. p. 742.

CHAP. III.

OF THE MOON.

Next to the sun, the moon is to mankind the most important and interesting of all the celestial bodies. Her conspicuous appearance in the heavens, the variety of her phases, and the rapidity with which she changes her place among the fixed stars, have rendered her at all times an object of admiration to the vulgar; while her proximity to the earth, her physical effects on the ocean, the intricacy of the theory of her motions, and the vast importance of that theory to navigation and geography, have equally

claimed the attention of the observer and mathematician; nor is there any other department of astronomy in which their researches have been crowned with more triumphant success, or been rewarded with more brilliant discoveries.

Sect. I.—*Of the Phases, Parallax, and Magnitude of the Moon.*

The different appearances or phases of the moon were probably the first celestial phenomena observed with any degree of attention. When the moon, after having been for some days invisible, is again seen on the eastern side of the sun, and at a distance of 20 or 30 degrees from him, she appears as a curved thread of silvery light; and her form is that of a crescent, the horns of which are turned towards the east. The breadth of the crescent increases continually in proportion as she separates herself from the sun, till, having obtained a distance of 90°, she appears under the form of a semicircle. At this point she is said to be in her *first quarter*. Continuing her motion to the eastward, the line which terminates the eastern side of her disk assumes the curvature of an elliptic arc, and her visible portion continues to increase till she has attained the distance of 180° from the sun, when she appears perfectly round. She is then *full*, and is said to be in *opposition*, rising as the sun sets, and consoling us by her pale light for the absence of the great luminary. Having passed this point, she begins to approach the sun; her western side now takes the form of the elliptic arc, and her luminous portion diminishes exactly in the same proportion as it increased through the first half of her orbit. About seven days after the full she again appears as a semicircle, the diameter of which is turned towards the west, and she is now at her *third quarter*, and at a distance of 90° from the sun. The semicircle after this changes into a crescent, and she continues to approach the sun, till, having advanced to within 20° or 30° from him, she again disappears, being lost in the splendour of his rays. These phases regularly succeed each other, and the time in which they run through all their changes is about 29½ days. When the moon passes the meridian at the same time with the sun, she is said to be in *Conjunction*. The two points of her orbit in which she is situated when in opposition or conjunction are called the *Syzygies;* those which are 90° distant from the sun are called the *Quadratures;* and the intermediate points between the syzygies and quadratures are called the *Octants*.

A slight attention to the lunar phases during a single revolution will be sufficient to prove that they are occasioned by the reflection of the sun's light from the opaque spherical surface of the moon. This fact, which was recognised in the earliest ages, will be made obvious by the help of a diagram. If the moon is an opaque body we can only see that portion of her enlightened side which is towards the earth. Therefore, when she arrives at that point Fig. 43. of her orbit A (fig. 43) where she is in conjunction with the sun S, her dark half is towards the earth, and she disappears, as at *a*, there being no light on that half to render it visible. When she comes to her first octant, at B, or has gone an eighth part of her orbit from her conjunction, a quarter of her enlightened side is towards the earth, and she appears horned, as at *b*. When she has gone a quarter of her orbit from her conjunction, to C, she shows us one half of her enlightened side, as at *c*, and we say she is a quarter old. At D she is in her second octant, and by showing us more of her enlightened side she appears gibbous, as at *d*. At E her whole enlightened side is towards the earth, and therefore she appears round, as at *e*, when we say it is full moon. In her third octant, at F, part of her dark side being towards the earth, she again appears gibbous, and is on the decrease, as at *f*. At G we see just one half of her enlightened side, and she appears as a semicircle, as at *g*. At H we only see a quarter of her enlightened side, being in her fourth octant, when she appears horned, as at *h*. And at A, having completed her course from the sun to the sun again, she disappears, and we say it is new moon. Thus, in going from A to E, the moon seems continually to increase; and in going from E to A, to decrease in the same proportion, exhibiting like phases at equal distances from A and E.

The magnitude of the visible portion of the moon's disk thus depends on the situation of the moon relatively to the sun and the earth, and is easily determined geometrically from her elongation or angular distance from the sun. Let ADBC (fig. 44) be the projection of the lunar Fig. 44. orb on the plane which passes through the centres of the sun, moon, and earth; let S be the place of the sun, E that of the earth, M the centre of the projection, and AB, CD two diameters perpendicular to SM and EM respectively, and let EM meet the circumference in G. It is evident that AGDB represents the hemisphere illuminated by the sun, and CAGD that which is visible from the earth; the whole portion of the visible disk, therefore, is represented by AGD, or by AG and DG. Now, if we conceive the moon's surface to be projected on the plane which passes through her centre perpendicular to the visual ray, the illuminated portion of the disk DG will appear as a semicircle, while the part GA will appear as a semi-ellipse, the minor axis of which is to its major as MF to MC, AF being perpendicular to MC. The eye at E will therefore see the semicircle DMG, together with the semi-ellipse GMA, and the visible part will be to the entire disk as DF : DC, that is, as $1 + \sin.\ AME : 2$, or, as $1 + \cos.\ \varphi : 2$; φ being equal to EMS the elongation of the earth from the sun as seen from the moon. The geocentric elongation of the moon from the sun, or the angle MES $= \psi$, may be substituted instead of φ, when we know the ratio of the distances ES $= r$ and MS $=$ R; for $\sin.\ \varphi = \frac{r}{R} \sin.\ \psi$, whence $\cos.\ \varphi = \sqrt{1 - \frac{r^2}{R^2} \sin.^2 \psi}$, and the above proportion becomes

$$DF : DC :: 1 + \sqrt{1 - \frac{r^2}{R^2} \sin.^2 \psi} : 2.$$

When the moon is in opposition the angle $\varphi = 0$, whence $1 + \cos.\ \varphi = 2$, and the whole disk is visible. At the conjunction $\varphi = 180°$, and $1 + \cos,\ \varphi = 0$; the moon is consequently invisible.

The triangle EMS likewise furnishes the means of finding the distance of the moon when that of the sun is known; or reciprocally, the distance of the sun from that of the moon: but for this purpose it is necessary to observe accurately the limit of illumination, which is not easily done. Let ADBE (fig. 45) be the illuminated part Fig. 45. of the moon ACBE. The distance between the cusps A and B, measured by the micrometer, gives the major axis of the ellipse ADB, and the semiconjugate axis DM is found by measuring in the same manner the distance ED, and subtracting EM, half the transverse AB. This gives $\frac{DM}{AM} = \cos.$ EMS (fig. 44); this gives the angle EMS or M; and from SEM, which is given by observation, we have ESM or S $= 180° -$ E $-$ M; whence M and S are given angles; and from the property of the triangle we have $EM = ES \frac{\sin.\ S}{\sin.\ M}$, or $ES = EM \frac{\sin.\ M}{\sin.\ S}$. The calculation would be greatly facilitated if the observation

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were made at the exact instant when the moon is dichotomized, or in her first or third quarter, for the elliptic arc then becomes a straight line and the angle EMS=90°; so that sin. M = 1. In this case therefore we have EM = ES sin. S = ES cos. E, and ES = $\frac{\text{EM}}{\text{cos. E}}$, which gives the ratio of the distances of the sun and moon. In this manner Aristarchus of Samos attempted to compare the distance of the two luminaries; and although his result was extremely erroneous, inasmuch as he found the distance of the sun to be only between eighteen and twenty times greater than that of the moon, whereas it is actually 380 times greater, yet the idea was an ingenious one, and the method perfectly accurate in theory. The error arose from the inaccuracy of the ancient instruments, and the impossibility of observing to within a few minutes the exact time of the dichotomy. Besides, as the angle at the sun is extremely small, a very slight error either with regard to the time or the angle has a great influence on the result.

Parallax of the moon.

The moon's absolute distance from the earth is obtained by means of her parallax, which, on account of her proximity, is very considerable, and can therefore be determined by the methods which were explained in chap. i. sect. 2. On comparing her parallaxes observed at different times, they are found to differ considerably in value. Thus, according to Lalande, the greatest horizontal parallax at Paris is 61′ 29″, the smallest 53′ 51″; and it assumes every possible value between these two extremes. The horizontal parallax being the angle which the earth's radius subtends at the moon, and consequently equal to the radius of the earth divided by the moon's distance, the perigean and apogean distances corresponding to the extreme parallaxes are respectively 55·916 and 63·842 semidiameters of the earth. The ratio of these two numbers, or of the extreme values of the parallax, is 1·1417, and denotes the greatest variations of the moon's distance from the earth. The ratio of the corresponding quantities in the case of the sun is only 1·034; hence the moon's distance is subject to much greater variations than that of the sun.

These differences in the value of the parallax arise from the variations of the moon's distance from the earth; but it is also observed to differ sensibly at different points of the earth's surface, even at the same instant of time. If the earth were spherical, the horizontal parallax of the moon, supposing her distance to be invariable, would be the same at whatever part of the earth it might be observed. The case is, however, different; for, on account of the spheroidal figure of the earth, the section made by every vertical plane gives a different ellipse, no one of which even passes through the centre of the earth, excepting indeed the cases in which the place of the observer is on the equator or under the pole; for in all other cases the perpendicular to the surface of the earth does not pass through its centre. Hence it is necessary, in speaking of the horizontal parallax, to specify the place of the observation.

Since the parallax of the moon is subject to incessant variation, it is necessary to assume a certain mean value of it, about which the true and apparent values may be conceived to oscillate. This is denominated the *constant* parallax. It is evident that it cannot be found by taking the arithmetical mean of the extreme values; for by reason of the disturbing force of the sun, the eccentricity of the lunar orbit, and consequently the perigean and apogean distances, are constantly varying; and as the quantity by which one of these distances is increased is not equal to that by which the other is diminished, it follows that the mean of the perigean and apogean parallaxes will not be a constant quantity, but different in successive revolutions of the moon. If we abstract from all the inequalities of the lunar orbit, and suppose the moon to be at her mean distance and mean place, the constant parallax will be the angle under which a given semidiameter of the earth is seen by a spectator at the moon in such circumstances. According to Lalande, the following are the values of the constant parallax:—

Under the equator	57′ 5″
Under the pole	56 53·2
For the latitude of Paris	56 58·3
For the radius of a sphere equal in volume to the earth	57 1

Magnitude of lunar or

The mean equatorial parallax being 57′ 5″, its double is 1° 54′ 10″, which expresses the angle subtended by the diameter of the earth at the distance of the moon. The angle subtended by the moon at the same distance is 31′ 26″; whence the diameter of the moon is to that of the earth as 31′ 26″ is to 1° 54′ 10″; that is, as ·524 to 1·899, or as 3 to 11 nearly. According to the tables of Burg, the accurate expression of the above ratio is 1 : 0·27293; hence the true diameter of the moon is 0·27293 diameters of the terrestrial equator. The surface of the moon is consequently $(0{\cdot}27293)^2 = 0{\cdot}0744908 = \frac{1}{13{\cdot}4243}$ of that of the earth, and its volume $(0{\cdot}27293)^3 = 0{\cdot}0203308 = \frac{1}{49{\cdot}1863}$, or, in round numbers, $\frac{1}{49}$th of the volume of the earth.

Sect. II.—*Of the Elements of the Lunar Orbit.*

1. *Nodes and Inclination of the Lunar Orbit.*—A few simple observations of the right ascensions and declinations of the moon suffice to show that her path is confined nearly to a plane, having only a small inclination to the plane of the ecliptic. If her path were rigorously confined to this plane, a single revolution would be sufficient to determine its inclination; but as numerous disturbing causes exist, which produce inequalities in all the elements of the lunar motion, it is only by taking the mean value of a great number of observations that these elements can be astronomically determined. In fixing the position of the plane of the orbit, the first object is to determine the straight line formed by its intersection with the plane of the ecliptic; that is to say, to determine the line of the *Nodes*. This would be at once accomplished if it were possible to observe the instant at which the moon's latitude is nothing; for at this instant her centre is in the plane of the ecliptic, and consequently her longitude is the same as the longitude of the node. But as the accuracy of modern practice requires that all important observations be made in the plane of the meridian, and as it could only happen by a very rare coincidence that the latitude deduced from the meridional right ascensions and declinations would be exactly zero, it is necessary to have recourse to a process of calculation to find the precise place of the node.

Let LNL′ (fig. 46) be a portion of the ecliptic, MNM′ of the lunar orbit, N the place of the node, and ML = l, M′L′ = l' be two latitudes on opposite sides of the ecliptic. The two right-angled triangles give, according to Napier's Rules, Fig. 46

$$\tan. \text{N} = \frac{\tan. l}{\sin. \text{NM}} = \frac{\tan. l'}{\sin. \text{NM}'};$$

therefore,

$$\frac{\sin. \text{NM}}{\sin. \text{NM}'} = \frac{\tan. l}{\tan. l'};$$

whence,

$$\frac{\sin. \text{NM} - \sin. \text{NM}'}{\sin. \text{NM} + \sin. \text{NM}'} = \frac{\tan. l - \tan. l'}{\tan. l + \tan. l'};$$

that is, by the trigonometrical formulæ,

$$\frac{\tan.\ \frac{1}{2}(NM - NM')}{\tan.\ \frac{1}{2}(NM + NM')} = \frac{\sin.\ (l - l')}{\sin.\ (l + l')},$$

$$\text{or } \tan.\ \tfrac{1}{2}(NM - NM') = \tan.\ \tfrac{1}{2}MM'.\ \frac{\sin.\ (l - l')}{\sin.\ (l + l')}.$$

Having therefore obtained an expression for the difference of NM and NM′, and knowing also their sum MM′, which is the difference of the longitudes of the moon at the time of the two observations, it is easy to deduce NM or NM′; consequently the longitude of the node is determined.

The *Ascending Node* of the lunar orbit is that point of the ecliptic through which the moon passes when she rises above the ecliptic towards the north pole: it is distinguished by the character ☊. The *Descending Node*, ☋, is the opposite point of the ecliptic, through which she passes when she descends below that plane towards the south pole. The nodes of the lunar orbit were anciently called the head and tail of the Dragon.

The position of the nodes is not fixed in the heavens. They move in a retrograde direction, or contrary to the order of the signs; and their motion is so rapid that its effects become very apparent after one or two revolutions. Regulus, a star of the first magnitude, is sometimes eclipsed by the moon; and as the latitude of this star is only about 27′ or 28′, it is certain that when that phenomenon occurs the moon is very near her node. Suppose it to be the ascending node: the month following it will be observed that the moon passes to the north of Regulus; and every succeeding month she will pass farther to the north of the same star, till at the end of four or five years, when her meridional altitude will be about 5° greater than that of Regulus. Having attained this elevation, her latitude begins to diminish; and, after a period of about nine years, Regulus is again eclipsed by the moon in her descent to the southern side of the ecliptic. The moon after this passes to the south of the star for the following nine years; and at the end of 18½ years the nodes have returned to their first position, after accomplishing a complete revolution. The same result is found from the observation of eclipses, the magnitude of which depends on the moon's latitude; and therefore, if the nodes remained fixed, the eclipses would always be of the same magnitude in the same quarter of the heavens. This, however, is not the case; and it is only after about 18½ years that they begin to return in the same order.

The mean retrograde motion of the nodes is found by the comparison of observations made at distant epochs to amount to 19° 19′ 42″·316 in a mean solar year, and the time in which they make a complete revolution is consequently 6798 days, 4 hours, 17 min. 43·18 sec. The longitude of the ascending node on the 1st of January 1801 was 13° 53′ 17″·7; hence its position at any other epoch is easily deduced, since we know the rate of its mean motion.

The inclination of the lunar orbit may be determined either by observing the moon's greatest latitudes, or it may be computed from the formula $\tan.\ N = \frac{\tan.\ l}{\sin.\ NM}$, when her latitude and distance from the node are known. The angle N, or the inclination, is observed to vary between 5° and 5° 17′ 35″. The mean inclination may therefore be taken at 5° 8′ 48″.

The retrograde motion of the moon's nodes, as well as all the other inequalities of the lunar motion, is occasioned by the attracting power of the sun, which varies in intensity with the sun's longitude, or distance from his perigee. The principal inequality to which the inclination of the lunar orbit is subject, is proportional to the cosine of double the sun's distance from the moon's ascending node. In fact, the sun and earth being always in the plane of the ecliptic, when the moon is also in that plane the action of the sun will have no tendency to increase or diminish her latitude; it will only affect her radius vector, or distance from the earth. But if the moon is not in the plane of the ecliptic, the sun's attracting force will not only affect her distance from the earth, but also tend to bring her nearer to the ecliptic; and this action will be greater in proportion to her deviation from that plane. When the nodes are in the quarters, and the limits of latitude in the syzygies, the inclination is 5°, as was found by Ptolemy; but when the nodes are in the syzygies, and the limits in the quarters, the inclination is 5° 17′ 35″. It has therefore a mean value of 5° 8′ 48″, when the nodes and limits coincide with the octants. Denoting therefore the greatest deviation from the mean values by x, this deviation will pass through all its values between $+x$ and $-x$ while the sun's distance from the ascending node varies from 0° to 90°. It may therefore be represented by a function which varies as the cosine of twice that distance, for the cosine of an angle runs through all its changes from $+1$ to -1 between 0 and 180°. Hence the equation which expresses the principal inequality of the moon's latitude is

(8′ 48″) cos. 2 ☉'s distance from ☽'s ☊.

The co-efficient 8′ 48″ is called, in astronomy, the *Co-efficient of the Argument*, the argument itself being the function by which the inequality is represented.

This periodic inequality of the moon's latitude was discovered by Tycho Brahe, from a comparison of the greatest latitudes at different epochs with the correponding positions of the moon with reference to her nodes. He observed that these latitudes oscillate about the mean value of 5° 8′ 48″; and as the greatest latitudes give immediately the inclination of the moon's orbit to the plane of the ecliptic, it necessarily followed that the inclination is subject to similar variations. The motion of the node of the lunar orbit is also subject to an inequality, depending on the same angle as the preceding, but proportional to its sine. Tycho explained these two inequalities by a very simple hypothesis, similar to that by which we have explained the oscillations of the terrestrial equator, namely, a slight nutation of the earth's axis. In the present case it is only necessary to place the mean pole of the lunar orbit at the distance of 5° 8′ 48″ from the pole of the ecliptic, and to suppose the true pole to describe a small ellipse about the mean pole in the same time that the sun occupies in making a semi-revolution with regard to the nodes of the moon's orbit, that is, in 173·309 days.

There are various other inequalities which affect the latitude of the moon and the inclination of her orbit, to correct which, no fewer than twelve equations are given in the recent and most accurate tables. The greater part of them are, however, only known from theory, and are so small that even their accumulated effects are scarcely perceptible to observation.

Phenomenon of the harvest-moon.

The inclination of the lunar orbit to the plane of the terrestrial equator occasions considerable differences in the intervals between the moon's rising or setting on successive days, and gives rise to the phenomenon of the *Harvest Moon*. As the daily motion of the moon is about 13 degrees from west to east, it follows that if she moved in a plane parallel to the equator, she would rise 50 minutes later every successive evening, because her orbit would then make the same angle with the horizon at all seasons of the year, and the intervals between her consecutive risings would be constant. For the sake of explanation, we may here suppose the moon to move in the plane of

the ecliptic. Now, the time in which a given arc of the ecliptic rises above the horizon depends on its inclination to the horizon. In our latitudes the inclination of the ecliptic at different points to the horizon varies so much, that at the first point of Aries an arc of 13° becomes visible in the short space of 17 minutes, while at the 23d of Leo the same arc will only rise above the horizon in one hour and 17 minutes. Hence, when the moon is near the first point of Aries, the difference of the times of her rising on two successive evenings will be only about 17 minutes; and as this happens in the course of every revolution, she will rise for two or three nights every month at nearly the same hour. But the rising of the moon is a phenomenon which attracts no attention, excepting about the time when she is full, that is, when she rises at sunset. In this case she is in opposition to the sun, and consequently, if she is in Aries, the sun must be in Libra, which happens during the autumnal months. At this season of the year, therefore, the moon, when near the full, rises for some evenings at nearly the same hour. This circumstance affords important advantages to the husbandman, on which account the phenomenon attracts particular attention.

It is obvious, that as this phenomenon is occasioned by the oblique position of the lunar orbit with regard to the equator, the effect will be greater than what has just been described if the plane of that orbit makes a greater angle with the equator than the plane of the ecliptic does. But we have seen that the plane of the moon's orbit is inclined to the ecliptic in an angle exceeding 5°; consequently, when her ascending node is in Aries, the angle which her orbit makes with the horizon will be 5° less than that which the ecliptic makes with the horizon; and the difference of time between her risings on two successive evenings will be less than 17 minutes, as would have been the case had her orbit coincided with the ecliptic. On the contrary, when the descending node comes to Aries, the angle which her orbit makes with the horizon will be greater by 5°, and consequently the difference of the times of her successive risings will be greater than if she moved in the plane of the ecliptic. If when the full moon is in Pisces or Aries the ascending node of her orbit is also in one of those signs, the difference of the times of her rising will not exceed one hour and forty minutes during a whole week; but when her nodes are differently situated, the difference in the time of her rising in the same signs may amount to $3\frac{1}{2}$ hours in the space of a week. In the former case the harvest-moons are the most beneficial, in the latter the least beneficial, to the husbandman. All the variations in the intervals between the consecutive risings or settings take place within the period in which the line of the nodes makes a complete revolution.

2. *Dimensions, Eccentricity, and Apsides of the Lunar Orbit; and the Inequalities of the Moon's motion.*—Since the moon moves in a plane orbit, the projection of her path on the surface of the celestial sphere will be a great circle. But the variations observable in the magnitude of her apparent diameter, and in the velocity of her motion, prove that if her orbit is a circle, the earth is at least not placed at its centre. The numerous perturbing causes which affect her motion render the exact determination of her orbit a matter of great difficulty; but observation shows that it deviates very little from an ellipse, of which the centre of the earth occupies one of the foci. It has also been found that the spaces passed over by the radius vector of the moon are very nearly proportional to the times of description; which is the distinctive character of the elliptic motion.

In order to obtain a correct idea of the figure and position of the orbit, it is necessary to know its major axis, its eccentricity, and the position of its apsides. The major axis is equal to the sum of the greatest and least distances, and these have already been stated to be respectively 63·842 and 55·916 semidiameters of the earth; whence, supposing the earth's radius to be 4000 miles, the major axis of the lunar orbit will amount in round numbers to 480,000 miles. It may be here remarked that the moon's distance is an element which may be practically determined with great exactness. A variation of 1″ in the parallax would occasion an error of only about 67 miles in the determination of the distance; therefore, since the parallax is certainly known to within 4″, the greatest error in the distance deduced from it cannot exceed 280 miles out of about 240,000 miles.

An approximation to the eccentricity of the orbit of the moon is easily obtained from the variations of her apparent diameter. The moon's apparent diameter is observed to vary between 29′ 30″ and 33′ 30″ very nearly. Now, let D denote the mean, D′ the apogean, D″ the perigean diameter, and e the eccentricity. We shall then have

$$D' = \frac{D}{1+e} = 29'\ 30''$$

$$D'' = \frac{D}{1-e} = 33'\ 30'',$$

$$\frac{D'}{D''} = \frac{1-e}{1+e} = \frac{29'\ 30''}{33'\ 30''};$$

whence we deduce

$$e = \frac{33'\ 30'' - 29'\ 30''}{33'\ 30'' + 29'\ 30''} = \frac{4'}{63'} = 0{\cdot}0635.$$

This eccentricity corresponds to an equation of the centre amounting to 7° 16′, and is much more considerable than that of the solar orbit, which, as we have before seen, amounts only to 0°·0168. The result just given is, however, only to be considered as approximative, and is, in fact, considerably too large. In the best and most recent tables the value assigned to the eccentricity of the lunar orbit is 0·0548442, and the corresponding equation of the centre 6° 17′ 12″·7. (See *Astronomical Tables and Formulæ*, by Francis Baily, Esq. London, 1827.)

The place of the apsides is likewise found from observations of the moon's apparent diameter, because at these points of the orbit the apparent magnitude has its maximum and minimum values. But as the apparent magnitude varies very slowly at the apsides, it is preferable, as Lalande remarks, to choose the points of mean distance where its variations are most rapid. Having selected two observations which give the same apparent diameter at two opposite points of the orbit, we shall have two points evidently at equal distances from the perigee, the longitude of which will therefore be given at the middle time between the two observations. In comparing the positions of the apsides thus determined at different epochs, it is found that they have a rapid progressive motion, that is, according to the order of the signs. In Mr Baily's tables the motion of the perigee is stated to be 4069°·046278, or 11 revolutions + 109° 2′ 46″·6, in 36525 mean solar days. Its mean motion in a mean solar day is consequently 6′ 41″; and in 365 mean solar days, 40° 39′ 46″·36. Hence the time in which it completes a sidereal revolution is 3232·575343 mean solar days. The period of a tropical revolution of the apsides is 3231·4751 mean solar days = 3231 days, 11 hours, 24 minutes, 0·8 seconds, or nearly 9 years. This mean motion of the lunar apsides is, however, subject to periodic inequalities of considerable magnitude, and therefore can only be determined accurately by means of observations separated from

each other by a long interval of time. In the tables just quoted, the epoch is the commencement of the present century, when the longitude of the perigee was in 266° 10′ 7″·5. From this and the rate of the mean motion, the longitude of the perigee at any other epoch may be easily computed.

Inequalities of the lunar orbit.

If the moon's place in her orbit were not subject to the influence of any disturbing force, her true longitude, or distance from the apsis, would be found at any instant from the theory of the elliptic motion, supposing her mean motion, or the time of a return to the same perigee or apogee, to be accurately known. Thus, supposing E to denote the maximum elliptic equation, which, as we have already stated, amounts to 6° 7′ 12″·7, we should have the true longitude = mean longitude + E sin. A, A being the moon's mean anomaly, and the longitudes counted from the perigee. This first equation or correction of the mean motion results solely from the circumstance that the moon moves in an elliptic orbit, according to the laws of Kepler, in the same manner as the sun and all the planets. Its argument is the mean anomaly A, and its period the anomalistic month. But the moon's longitudes, as determined in this manner, are far from agreeing with observation; and several other corrections must be applied, the accurate determination of which forms the principal object of the lunar theory.

Equation of the centre.

Evection.

After the equation of the centre, the most considerable of the inequalities of the moon's longitude is that to which Boulliaud gave the name of the *Evection*. It was noticed by Hipparchus; but it was Ptolemy who discovered its law, and gave a construction which represents its general effects with great accuracy. These effects are to diminish the equation of the centre when the line of the apsides lies in syzygy, and to augment it when the same line lies in quadratures. Thus, supposing the apsides to lie in syzygy, and that it is sought to compute the moon's true longitude about seven days after she has left the perigee, by adding the equation of the centre to the mean anomaly, the resulting longitude will be found to be above 80′ *less* than that which is given by observation. But if the line of the apsides lies in quadratures, the place of the moon at about the same distance, that is, 90° from the perigee, computed in the same manner, will be found to be before the observed place by above 80′; that is, the computed will be *greater* than the observed longitude, by more than 80 minutes. After a long series of observations, astronomers have found that the inequality in question is represented with great exactness, by supposing it proportional to the sine of twice the mean angular distance of the moon from the sun, minus the mean anomaly of the moon. In Baily's tables, its maximum value is stated to be 1° 20′ 29″·9; whence, representing the angular distance of the sun and moon by ☽ — ☉, and the mean anomaly as before by A, the correction due to the evection will be

$$(1^\circ\ 20'\ 29''{\cdot}9)\ \text{sin.}\ [2(☽ - ☉) - A].$$

Variation.

A third inequality of the lunar motion, called the *Variation*, was discovered by Tycho Brahe, who found that the moon's place, calculated from her mean motion, the equation of the centre, and the evection, does not always agree with the true place, and that the variations are greatest in the octants, or when the line of the apsides makes an angle of 45° with that of the syzygies and quadratures. Having observed the moon at different points of her orbit, he found that this correction has no dependence on the position of the apsides, but only on the moon's elongation from the sun. Its maximum value is additive in the octants which come immediately *after* the syzygies, where the elongation is 45°, or 180° + 45°, and subtractive in the octants which *precede* the syzygies, where the elongation is 360° — 45°, and 180° — 45°. It vanishes altogether in the syzygies and quadratures where the elongation is 0°, 180°, 90°, or 270°; and on this account it was not perceived by the ancient astronomers, who only observed the moon in those positions. It will be readily perceived, from the limits between which it varies, that it is proportional to the sine of twice the angular distance between the sun and moon. Its maximum value, or the co-efficient of its argument, is 35′ 41″·9; hence the correction necessary on account of it is represented by the formula

$$(35'\ 41''{\cdot}9)\ \text{sin.}\ 2\ (☽ - ☉).$$

Annual equation.

When this equation is added to the two preceding ones, the differences between the computed and observed places of the moon are brought within narrower limits; but they do not yet disappear altogether except in the months of June and December, and about the time of the equinoxes they are found to amount to eleven or twelve minutes. This inequality was observed by Tycho and Kepler, though neither of them determined its magnitude. They supposed it to be an equation of time peculiar to the moon; and under this form Horrox inserted it in his tables, assigning its maximum value at 11′ 16″, which differs only by four seconds from that which is obtained from the most accurate modern observations. On account that it is regulated by the seasons, and depends not on the lunar orbit, but the anomaly of the sun, Kepler gave it the name of the *Annual Equation*. By reason of this inequality the motion of the moon is slower than the mean motion during the winter months, when the motion of the sun is most rapid; and, on the contrary, is most rapid in summer, when the sun's motion is slowest. Hence its argument is the same as that of the equation of the centre of the sun, but with a contrary sign. It is therefore proportional to the sine of the sun's mean anomaly; its period is the anomalistic year, and its maximum value is found by observation to be 11′ 11″·9; hence it is expressed by the formula

$$(11'\ 11''{\cdot}9)\ \text{sin.}\ ☉\text{'s mean anomaly.}$$

If we now collect these equations we shall obtain the following corrected expression of the moon's true place:

$$\begin{aligned} ☽\text{'s true longitude} = ☽\text{'s mean longitude,} \\ &+ (6^\circ\ 17'\ 12''{\cdot}7)\ \text{sin.}\ A \\ &+ (1^\circ\ 20'\ 29''{\cdot}9)\ \text{sin.}\ [2(☽ - ☉) - A] \\ &- (\ \ 35'\ 41''{\cdot}9)\ \text{sin.}\ 2\ (☽ - ☉) \\ &- (\ \ 11'\ 11''{\cdot}9)\ \text{sin.}\ ☉\text{'s mean anomaly.} \end{aligned}$$

For the physical cause of the three last-mentioned inequalities, viz. the evection, the variation, and the annual equation, see *Physical Astronomy*, sect. ii. par. 37, 38, and 39. They are the principal but not the only periodic inequalities which affect the longitude of the moon; for the profound investigations of modern science have detected many others, which, by reason of their small values, and the manner in which they are blended with one another, would have eluded all attempts to discover their period or their law by observation alone. Observation can make known only the joint effect of the independent equations, and thereby indicate their existence. In order to separate them and determine their respective values, it is indispensable to have recourse to the physical theory, from which alone the various circumstances of the lunar motion can be properly determined. Newton was the first who attempted to compute *a priori* the inequalities of the moon's motion, and thereby led the way in a research which was prosecuted with infinite ingenuity and profound analytical skill by D'Alembert, Clairaut, Euler, and other illustrious mathematicians of the last century, and which was only brought to a successful termination by the labours of Laplace. The formulæ given in the seventh

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book of the *Mécanique Céleste*, for a great number of new inequalities derived from the theory of attraction, form the basis of the lunar tables of Burg and Burckhardt. It is to these theoretical researches that we are indebted for the precision with which the moon's motion is actually known, and the great advantages which thence result to geography and navigation. The recent tables contain no fewer than twenty-eight equations of longitude, all which may be regarded as corrections of the mean values of the four which we have explained, and which are themselves corrections of the mean motion. It is thus that astronomy approaches nearer and nearer, by every successive step, to the last term of a series which would represent the orbits and motions of the celestial bodies with absolute accuracy.

Acceleration of the mean motion of the moon.

The lunar inequalities which we have as yet considered are all of a periodic nature, are compensated in the course of a comparatively small number of years, and have passed through many complete revolutions since the commencement of the history of astronomical observations. But there are, as in the case of the sun, others of a different kind, the periods of which are so long that, with reference to the duration of human life, they may be considered as permanently affecting the elements of the lunar orbit. These are the *Secular Inequalities*, the most remarkable of which is the acceleration of the moon's mean motion.

On comparing the lunar observations made within the last two centuries with one another, there results a mean secular motion greater than that which is given by comparing them with those made by Ebn-Jounis, near Cairo, towards the end of the 10th century, and greater still than that which is given by comparing them with observations of eclipses made at Babylon in the years 719, 720, and 721 before our era, and preserved by Ptolemy in the *Almagest*. These comparisons, which have been made by different astronomers with the utmost care, prove incontestably the acceleration of the motion of the moon from the Chaldeans to the Arabians, and from the Arabians to the present times.

The acceleration of the moon's mean motion was first remarked by Dr Halley, and mentioned in his *Notes* on the observations of Albategnius, inserted in the *Philosophical Transactions* for 1693. It was fully confirmed by Dunthorne, who was led by the discussion of a great number of ancient observations of eclipses, to suppose that it proceeded uniformly at the rate of 10″ in a hundred years; a supposition which consequently gave him a correction for the mean longitude of the moon proportional to the square of the time, or of 10″ multiplied by the square of the number of years elapsed between 1700 and the epoch of the calculation. This was the first attempt to estimate the value of the secular equation, which had hitherto been confounded with the mean secular motion. By a similar discussion of ancient observations, Mayer was likewise led to a secular equation proportional to the square of the time, which, in his first *Lunar Tables*, published in 1753, he valued at 7″ for the first century, counting from the year 1700, but which he advanced to 9″ in his last tables, published in 1770. Lalande found it to amount to 9″·886, and therefore agreed with Dunthorne in estimating the acceleration at 10″ for the first century after 1700. Delambre subsequently undertook to determine accurately the actual motion of the moon in a century, from a comparison of the best modern observations. He found it to amount to 307° 53′ 9″ (rejecting the circumferences), while the most ancient observations agree in making it less by 3 or 4 minutes. The equation, which, in consequence of these comparisons, was empirically introduced into the tables, has been confirmed by the theory of gravitation; and the discovery of the physical cause, and of the law of the acceleration, due to Laplace, forms one of the most brilliant triumphs of modern science. In 1786 Laplace demonstrated that the acceleration is one of the effects of the attraction of the sun, and connected with the variations of the eccentricity of the earth's orbit in such a manner that the moon will continue to be accelerated while the eccentricity diminishes, but that it will disappear when the eccentricity has reached its maximum value; and when that element begins to increase, the mean motion of the moon will be retarded.

In order to take into account the effects of the acceleration in the determination of the mean longitude, M. Damoiseau has given the following formula for the secular variation; $10''\cdot7232\, n^2 + 0''\cdot019361\, n^3$, where n is the number of centuries from 1801; so that if L is the mean longitude of the moon on the 1st of January 1801, and m is the secular motion at that epoch, the mean longitude will be $L + mn + 10''\cdot7232\, n^2 + 0''\cdot019361\, n^3$ after n centuries. By means of this equation the tables satisfy the most ancient observations, and may be extended to at least a thousand years from the present epoch. It is only necessary to observe, that, in applying the formula, n must be taken negatively, if the epoch is anterior to 1801.

Secular inequalities of the perigee and nodes.

The same cause which gives rise to the acceleration of the mean motion, namely, the diminution of the eccentricity of the earth's orbit, also occasions secular inequalities in motion of the perigee and nodes of the orbit of the moon. These two inequalities are, however, affected with opposite signs to that of the former; that is, while the mean motion of the moon is accelerated, the motion of her perigee and that of her nodes are retarded. They were deduced by Laplace from theory, and the equations by which they are expressed are connected with one another by a very simple ratio. If we take A to represent the secular acceleration of the mean motion, the secular variation of the perigee found by Laplace is — 4·00052 A, and that of the nodes — 0·735452 A. From this Laplace concluded that the three motions of the moon, with respect to the sun, to her perigee, and to her nodes, are accelerated, and that their secular equations are in the ratio of the above numbers. By pushing the approximations to a great length, MM. Plana and Carlini, and M. Damoiseau, in *Memoirs* which obtained the prize of the Academy of Sciences for 1820, have found different numbers; those of Damoiseau are 1, 4·702, and 0·612. These important results of theory are all confirmed by observation.

The three secular inequalities which have been pointed out will obviously occasion others; for all quantities depending on the mean motion, the motion of the perigee, or of the nodes, must be in some degree modified by them. Thus the mean anomaly, which is the difference of the mean longitude of the moon and the mean longitude of the perigee, is subject to a secular equation equal to the difference of the secular equations affecting the longitudes of the moon and the perigee. The radius vector, the eccentricity and inclination of the orbit, are affected by the secular inequality of the mean motion, which, although too minute to have been hitherto appreciable, will acquire sensible values in the course of ages. The major axis of the ellipse is the only element exempted from inequalities of this sort. It is not probable, however, that the utmost efforts of science will ever make us acquainted with all the irregularities to which the moon's motion is subject. They can only be developed by the complete integration of the differential equations of motion; an integration which is laboriously performed term by term, and which, when attempted to be carried beyond a certain point, transcends

the limits of human patience and industry. What is most essential is to select, among the multitude of terms, such as may possibly acquire considerable co-efficients by integration.

The following table exhibits in one view the different elements of the lunar orbit. The epoch is the commencement of the present century.

Mean inclination to the plane of the ecliptic	5°	8′	47″·9
Longitude of ascending node	12	53	17 ·7
Motion of node in 365 mean solar days	19	19	42 ·316
Longitude of perigee	266	10	7 ·5
Mean motion of perigee in 365 mean solar days	40	39	45 ·36
Mean longitude	118	17	8 ·3
Greatest equation of the centre	6	17	12 ·7
Eccentricity	0·0548442		
Mean distance from the earth in diameters of the terrestrial equator	29·982075		

Sect. III.—*Of the different Species of Lunar Months.*

In treating of the sun, we took notice of three different species of revolutions or years, namely, the mean solar year, or the interval of time which the sun employs in performing a complete revolution with regard to the equinoxes; the sidereal year, or the time in which he returns to the same fixed star; and the anomalistic year, or the time in which he returns to the same point of his ellipse. In like manner, if we understand by the term *month* the time which the moon employs to make an entire revolution relatively to any given point, movable or fixed, we shall have as many different species of months as there are different motions with which that of the moon can be compared. For example, if we estimate her revolution relatively to the sun, the month will be the time which elapses between two consecutive conjunctions or oppositions. This is called the *synodic month, lunar month,* or *lunation.* If we consider her revolution as completed when she has gone through 360° of longitude counted from the movable equinox, we shall have the *tropical* or *periodic month.* The interval between two successive conjunctions with the same fixed star is the *sidereal month.* A revolution with regard to the apsides of her orbit, that is to say, the time in which she returns to her perigee or apogee, gives the *anomalistic month:* and, finally, the revolution with regard to the nodes is the *nodical* or *draconitic month.*

Of these different periods the most important to mankind is the synodic month. It is also that which, by reason of the striking manner in which it is marked out by the phases of the moon, would first offer itself to the attention of the observer; and when its period is accurately determined, the other months may be deduced from it without difficulty, when the relative motions of the sun and moon are known with sufficient precision. The eclipses furnish a simple means of determining the synodic revolution with a great degree of accuracy. A few rude observations suffice to show that the period of a lunation is very nearly 29½ days; and with this knowledge we are in a condition to compare two distant eclipses without running any risk of mistaking the number of revolutions that have taken place in the interval. The most ancient observation recorded by Ptolemy is an eclipse of the moon, which happened 720 years B. C., on the 19th of March, at 6 hours 48 minutes mean time at Paris, according to Lalande. In order to make use of this observation directly for the purpose of determining the synodic revolution, it is necessary to compare it with another of the same kind in which the moon occupied the same point of her ellipse, or the same position relatively to her apsides; for as it is the *true* place of the moon which is observed, and the *mean* motion which we are in quest of, the equation of the centre ought to be the same in both observations. Now, a similar observation is furnished by an eclipse which happened in 1717, on the 9th of September, at 6 hours 2 minutes, the moon's anomaly being very nearly the same as in the Babylonian observation. In the interval between the two observations the moon had therefore completed a whole number of revolutions, with regard to her mean as well as her true motion. The interval between the eclipses is 2437 years and 174 days minus 46 minutes, which expressed in days is 890287·9680555... days. In this interval it is found, from the approximate value of 29½ days, that 30148 synodic revolutions had happened; hence the mean length of the synodic month is $= \frac{890287{\cdot}968055}{30148} = 29$ days 12 hours 44 min. 2·8497 sec.

To deduce the other revolutions, let N = the number of days in a synodic month, n the number of synodic revolutions in the interval between the two observations, m the mean motion of the sun, and T the time of a tropical revolution. We shall then have the proportion $T : N :: 360° : n{\cdot}360° + m$; whence

$$T = \frac{N{\cdot}360°}{n{\cdot}360° + m} = \frac{N}{n + \frac{m}{360°}} = \frac{\left(\frac{N}{n}\right)}{1 + \frac{m}{n{\cdot}360°}}$$

$$= \frac{N}{n}\left\{1 - \frac{m}{n{\cdot}360°} + \left(\frac{m}{n{\cdot}360°}\right)^2 - \&c.\right\}.$$

Let S = the time of a sidereal revolution. The value of S is immediately found from T; for let p = the precession of the equinoxes in the time T, we shall have $S : T :: 360° : 360° - p$; whence

$$S = \frac{T{\cdot}360°}{360° - p} = \frac{T}{1 - \frac{p}{360°}}$$

$$= T\left\{1 + \frac{p}{360°} + \left(\frac{p}{360°}\right)^2 + \&c.\right\}.$$

In like manner, if we represent by u the motion of the apside, and by v that of the node, in the time T, the times of the anomalistic and nodical revolutions will be respectively obtained by the substitution of u and $-v$ (the motion of the node being retrograde) in the last formula in place of p. Instead, however, of proceeding in this manner, it is better to assume as the basis of the calculation the mean motion of the moon in longitude, which is accurately known by the observations of 2000 years, and thence to deduce the time of the mean tropical revolution.

The mean motion of the moon in 100 Julian years, or 36525 days, is found to be 1336 circumferences + 307° 52′ 43″·5; or, by reducing the degrees, &c. to the fraction of a circumference, 1336·85521875 circumferences. The periodic month is therefore $\frac{35625}{1336{\cdot}85221875}$ days. In order to reduce the denominator of this fraction to a smaller number of digits, we may divide its terms by 3, multiply them by 32, then divide them by 900, and there will result $\frac{432{\cdot}888...}{15{\cdot}84421}$, the denominator of which contains only 7 digits in place of 12. On performing the division, we shall find the periodic month or tropical revolution = 27·321582388 days = 27 days 7 hours 43 min. 4·7183 sec.

The mean motion of the moon in 36525 days is.....1336c 307° 52′ 43″·5
that of the sun.....100 0 45 45

hence the relative motion is.....1236c 307° 6′ 58″·5 = 445267·11625 degrees. The time of a synodic revolution is therefore $\frac{360 \times 36525}{445267 \cdot 11625}$ days; or, multiplying numerator and denominator by 800, $= \frac{10519200000}{356213693}$; whence the synodic month is 29·5305885391 days = 29 days 12 hours 44 min. 2·849778 sec.

In order to obtain the sidereal revolution, we subtract the secular motion of the equinoctial points = 5010″ = 1° 23′ 30″ from the moon's tropical revolution; the remainder, which gives the sidereal motion of the moon in 36525 days, is 1336c 306° 29′ 13″·5 = 481266·4870833 degrees. Hence the time of a sidereal revolution is $\frac{360 \times 36525}{481266 \cdot 4870833}$ days. On multiplying the terms of this fraction by 2400, it is reduced to $\frac{31557600000}{1155039569}$, which gives the sidereal month = 27 days 7 hours 43 min. 11·544375 sec.

In like manner, by subtracting the motion of the perigee in 100 years from the secular motion of the moon, we shall find the anomalistic revolution to be 27 days 13 hours 18 min. 34·9488 sec.; and by adding the retrograde secular motion of the node to the secular motion of the moon, the revolution in respect of the nodes is found to be performed in 27 days 5 hours 5 min. 35·60769 sec.

The following table exhibits the different kinds of lunar periods and motions:—

	Days.	Ho.	Min.	Sec.	Days.
Synodic revolution	29	12	44	2·84	= 29·5305887
Tropical	27	7	43	4·71	= 27·3215824
Sidereal	27	7	43	11·54	= 27·3216614
Anomalistic	27	13	18	37·40	= 27·5545995
Nodical	27	5	5	35·60	= 27·2122176
Tropical revolution of node	6728	4	17	43·18	= 6798·1789720
Sidereal	6793	6	59	15·34	= 6793·2911498

☾'s mean tropical daily motion.....13° 10′ 35″·027
☾'s mean sidereal daily motion.....13° 10′ 34″·889
☾'s daily motion in respect of node.....13° 13′ 45″·534

According to Ptolemy, the synodic month is 29 days 12 hours 44 min. 3½ sec., which differs from the above only by half a second. The same great astronomer made the tropical month to consist of 27 days 7 hours 43 min. 7¼ sec. which exceeds the true time by 2½ seconds; an error into which he was led by assigning too great a value to the mean motion of the sun.

The ancient astronomers paid great attention to these different revolutions, for the purpose of regulating their lunisolar calendar, and of avoiding the calculation of eclipses, which is attended with difficulties that to them must have proved almost insuperable. Their object was therefore to assign composite periods, after the revolution of which the eclipses would again return in the same order. Now, it is easy to see that a period which will bring back eclipses of the same magnitude and duration, on the same day of the year and at the same longitude, must be an exact multiple of the different lunar months. The return of the moon to the same distance from her node will give an eclipse of the same magnitude; if she returns at the same time to the same point of her orbit, the eclipse will also be of the same duration; and if, in addition to these circumstances, she has also returned to the same longitude, the eclipse will take place on the same day of the year. But the numbers in the above table being incommensurable, it is impossible to find any period, however long, that will embrace all these conditions; the ancients therefore formed periods of different lengths, according as they aimed at satisfying the different conditions with a greater or less degree of precision. For an account of some of the most remarkable of the ancient lunisolar periods, see CALENDAR.

On account of the acceleration of the mean motion of the moon, the ratios of the different species of months are constantly undergoing alterations, and therefore the different cycles, supposing them exact at the time of their formation, cannot continue so for an indefinite length of time. This circumstance is, however, little to be regretted; for, in the present state of astronomical science, they are not of any great use, inasmuch as we are in possession of surer methods of predicting eclipses, the calculation of which, from the ephemerides, is now a matter of comparative facility. They are, however, interesting in an historical point of view, and their formation was a principal object of the labours of the early astronomers. (On this subject see Lalande, *Astronomie*, tome ii. p. 185; Delambre, *Astronomie Théorique et Pratique*, tome ii. p. 319; Schubert, *Traité d'Astronomie Théorique*, tome ii.; Woodhouse's *Astronomy*, p. 665.)

END OF VOLUME THIRD.

Engd. by G. Aikman Edin.

Theoretical Astronomy.

The mean motion of the moon in 36525 days is.....[illegible]
that of the sun.....[illegible]

hence the relative motion is.....[illegible] = 445267·11625 degrees. The time of a synodic revolution is therefore $\frac{360 \times 36525}{445267 \cdot 11625}$ days; or, multiplying numerator and denominator by 800, $= \frac{10519200000}{356213693}$; whence the synodic month is 29·5305885391 days = 29 days 12 hours 44 min. 2·849778 sec.

In order to obtain the sidereal revolution, we subtract the secular motion of the equinoctial points = 5010″ = 1° 23′ 30″ from the moon's tropical revolution; the remainder, which gives the sidereal motion of the moon in 36525 days, is 1336ᶜ 306° 29′ 13″·5 = 481266·4870833 degrees. Hence the time of a sidereal revolution is $\frac{360 \times 36525}{481266 \cdot 4870833}$ days. On multiplying the terms of this fraction by 2400, it is reduced to $\frac{31557600000}{1155039569}$, which gives the sidereal month = 27 days 7 hours 43 min. 11·544375 sec.

In like manner, by subtracting the motion of the perigee in 100 years from the secular motion of the moon, we shall find the anomalistic revolution to be 27 days 13 hours 18 min. 34·9488 sec.; and by adding the retrograde secular motion of the node to the secular motion of the moon, the revolution in respect of the node is found to be performed in 27 days 5 hours 5 min. 35·60 sec.

The following table exhibits the different kinds of lunar periods and motions:—

	Days.	Hr.	Min.	Sec.	Days.
Synodic revolution....	29	12	44	[illegible]	= [illegible]5887
Tropical.....	27	7	43	[illegible]	= [illegible]824
Sidereal.....	27	7	43	11·54	= [illegible]414
Anomalistic.....	27	13	18	37·40	= [illegible]
Nodical.....	27	5	5	35·60	= 27·3122176
Tropical revolution of node }	6728	4	17	43·18	= 6798·1789720
Sidereal.....	6793	6	59	15·34	= 6793·2911498

☾'s mean tropical daily motion.....13° 10′ 35″·027
☾'s mean sidereal daily motion.....13° 10′ 34″·889
☾'s daily motion in respect of node.....13° 13′ 45″·534

According to Ptolemy, the synodic month is 29 days 12 hours 44 min. 3½ sec., which differs from the [illegible] only by half a second. The same great astronomer [illegible] the tropical month to consist of 27 days 7 hours [illegible] 7½ sec. which exceeds the true time by 2½ seconds [illegible] into which he was led by assigning too great a [illegible] to the mean motion of the sun.

The ancient astronomers paid great attention to [illegible] different revolutions, for the purpose of regulating [illegible] lunisolar calendar, and of avoiding the calculation [illegible] eclipses, which is attended with difficulties that to them must have proved almost insuperable. Their object was therefore to assign composite periods, after the revolution of which the eclipses would again return in the same order. Now, it is easy to see that a period which will bring back eclipses of the same magnitude and duration, on the same day of the year and at the same longitude, must be an exact multiple of the different lunar months. The return of the moon to the same distance from her node will give an eclipse of the same magnitude; if she returns at the same time to the same point of her orbit, the eclipse will also be of the same duration; and if, in addition to these circumstances, she has also returned to the same longitude, the eclipse will take place on the same day of the year. But the numbers in the above [illegible] being incommensurable, it is impossible to find any period, however long, that will embrace all these conditions; the ancients therefore formed periods of different lengths according as they aimed at satisfying the different conditions with a greater or less degree of precision. For an account of some of the most remarkable of the [illegible] lunisolar periods, see CALENDAR.

On account of the acceleration of the mean motion of the moon, the ratios of the different species of months are constantly undergoing alterations, and therefore the different cycles, supposing them exact at the time of [illegible] formation, cannot continue so for an indefinite length of time. This circumstance is, however, little to be regretted; for, in the present state of astronomical [illegible] they are not of any great use, inasmuch as we [illegible] possession of surer methods of predicting eclipses, [illegible] calculation of which, from the ephemerides, is now a matter of comparative facility. They are, however, interesting in an historical point of view, and their formation [illegible] a principal object of the labours of the early astronomers. (On this subject see Lalande, *Astronomie*, tome ii. [illegible] Delambre, *Astronomie Théorique et Pratique*, tome ii. [illegible] Schubert, *Traité d'Astronomie Théorique*, tome ii.; [illegible] house's *Astronomy*, p. 665.)

END OF VOLUME THIRD.

Fig. 1

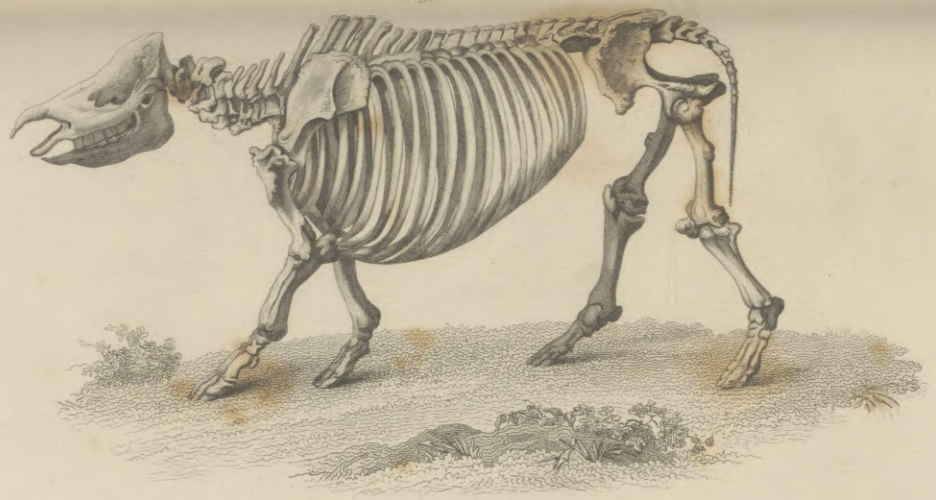

Fig. 2

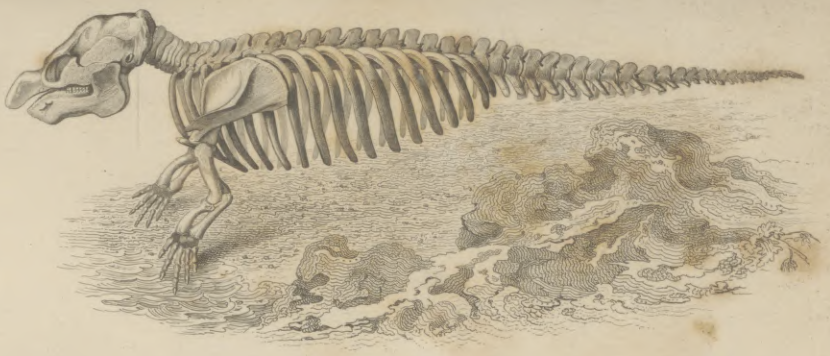

Fig. 4

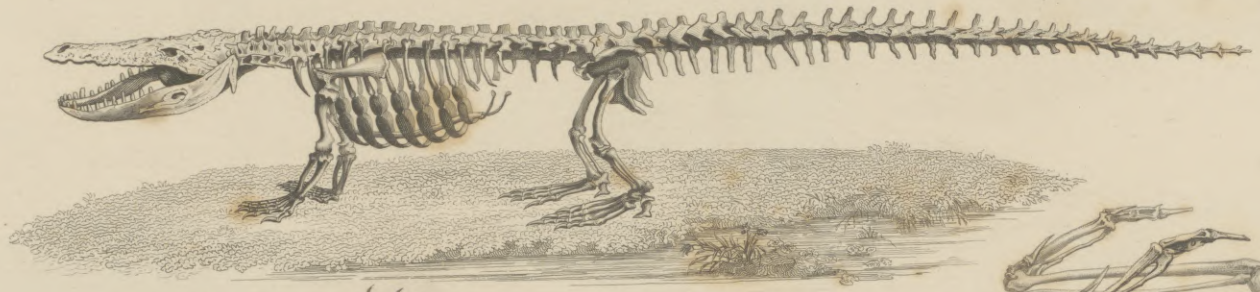

Fig. 5

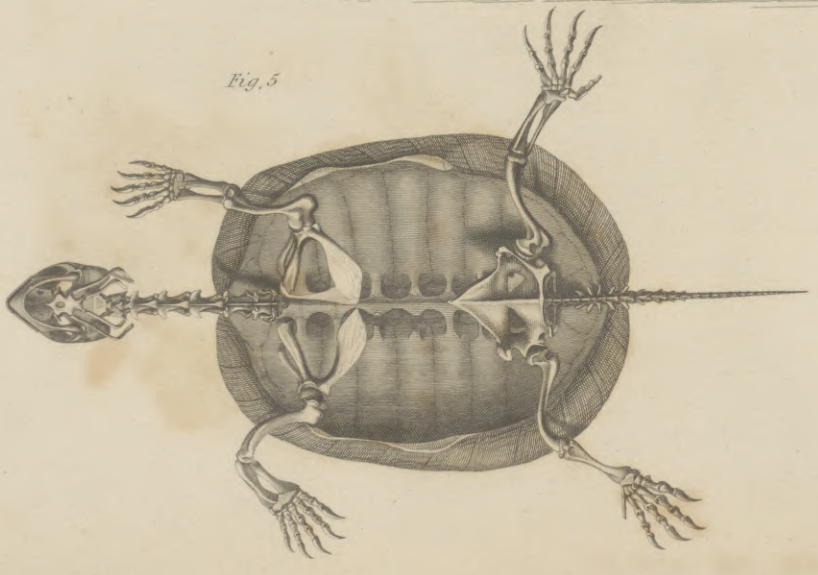

Fig. 3

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ANATOMY.

COMPARATIVE.

PLATE XXXV.

Fig. 1

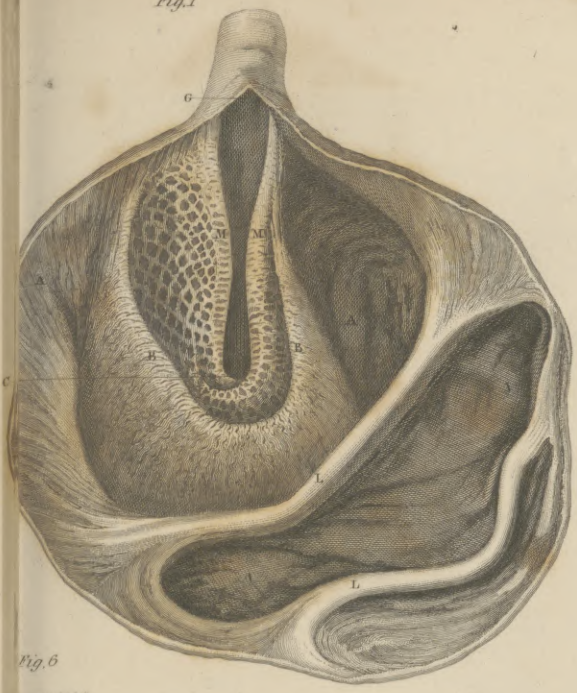


Fig. 2

Fig. 6

Fig. 5

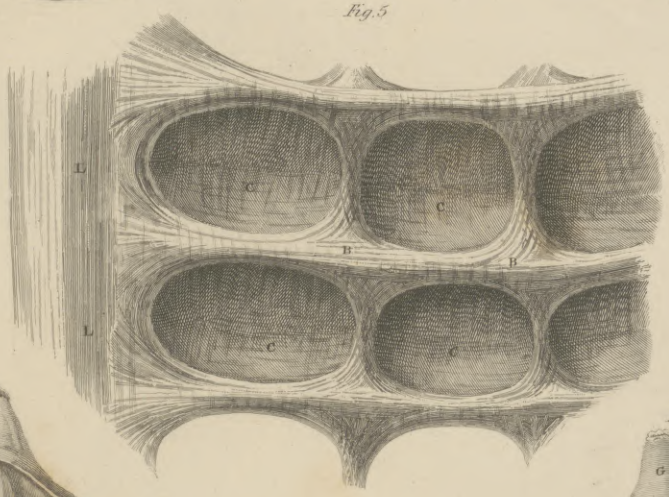


Fig. 7

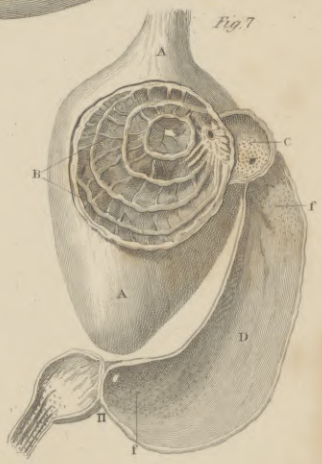


Fig. 3

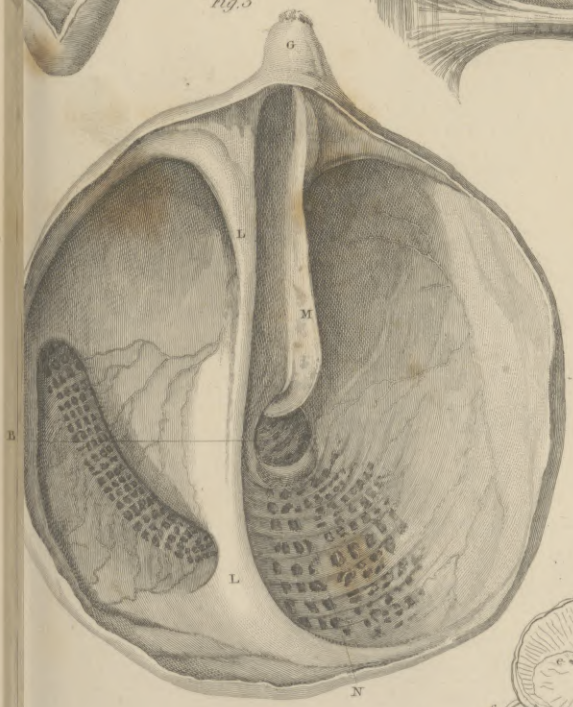


Fig. 4

Fig. 8

Engd by G. Aikman, Edinr.

ANATOMY.

COMPARATIVE.

PLATE XXXVI.

Fig. 1.

Fig. 2.

Fig. 3.

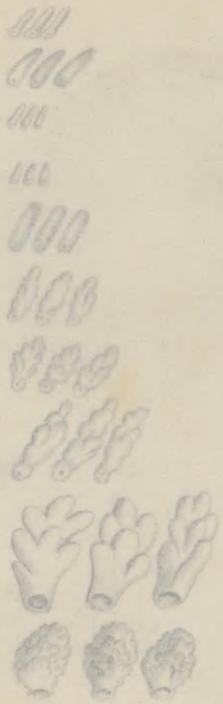


Fig. 4.

Fig. 5.

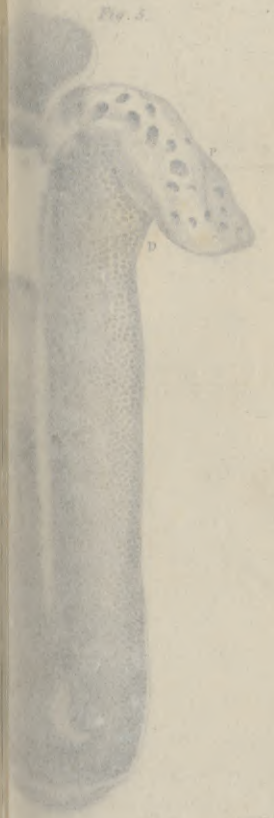


Fig. 6.

Fig. 7.

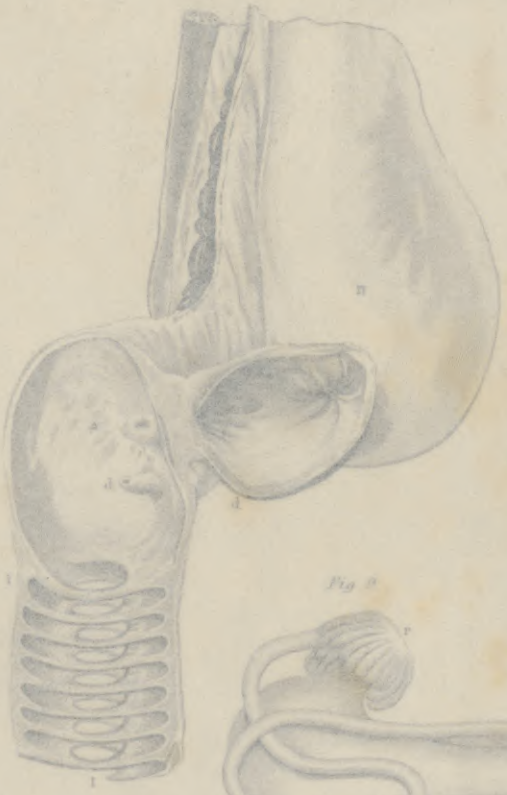


Fig. 8.

Fig. 9.

Engd by G. Kilman, Edinr.

ANATOMY.

COMPARATIVE.

PLATE XXXVI.

Fig. 1.

Fig. 2.

Fig. 3.

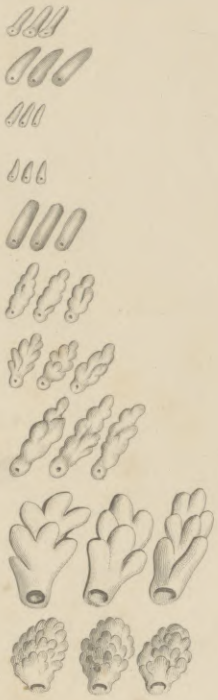


Fig. 4.

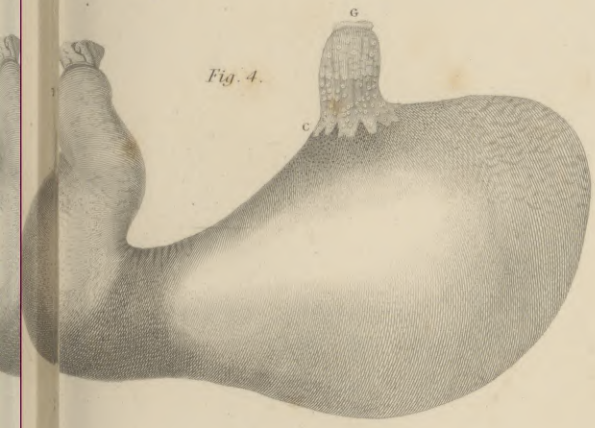


Fig. 5.

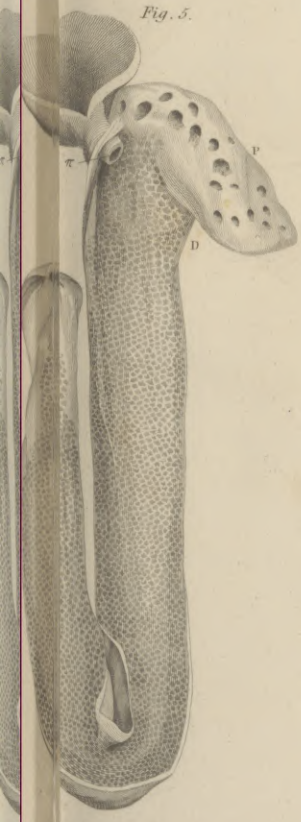


Fig. 6.

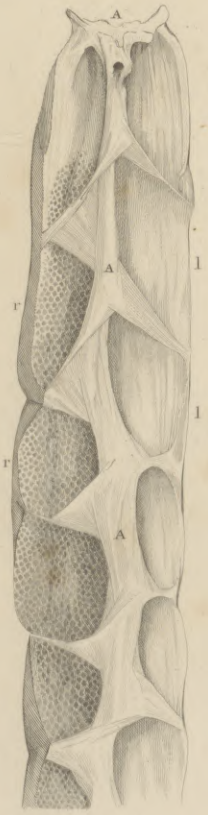


Fig. 7.

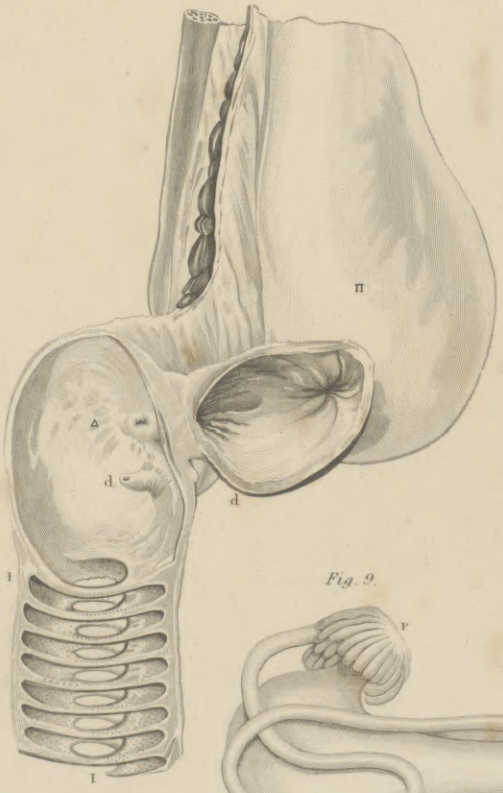


Fig. 8.

Fig. 9.

Engd by G. Aikman, Edin.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

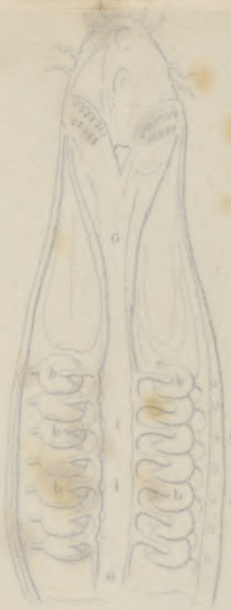


Fig. 5.

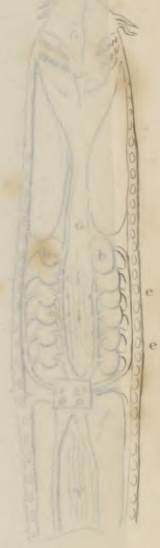


Fig. 6.

Fig. 12.

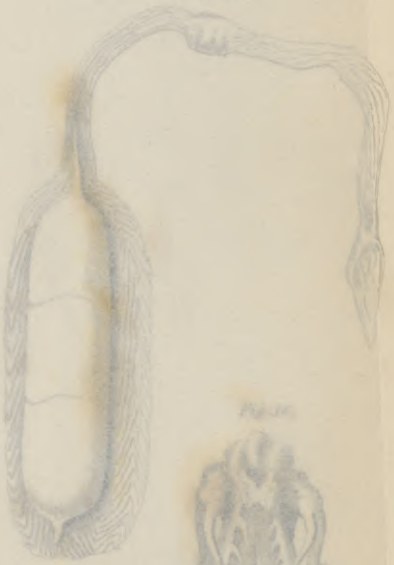


Fig. 11.

Fig. 16.

Fig. 14.

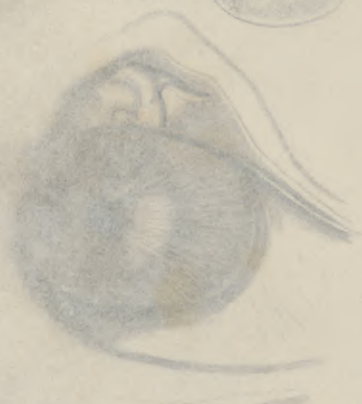


Fig. 15.

Fig. 17.

Fig. 18.

ANATOMY.

COMPARATIVE.

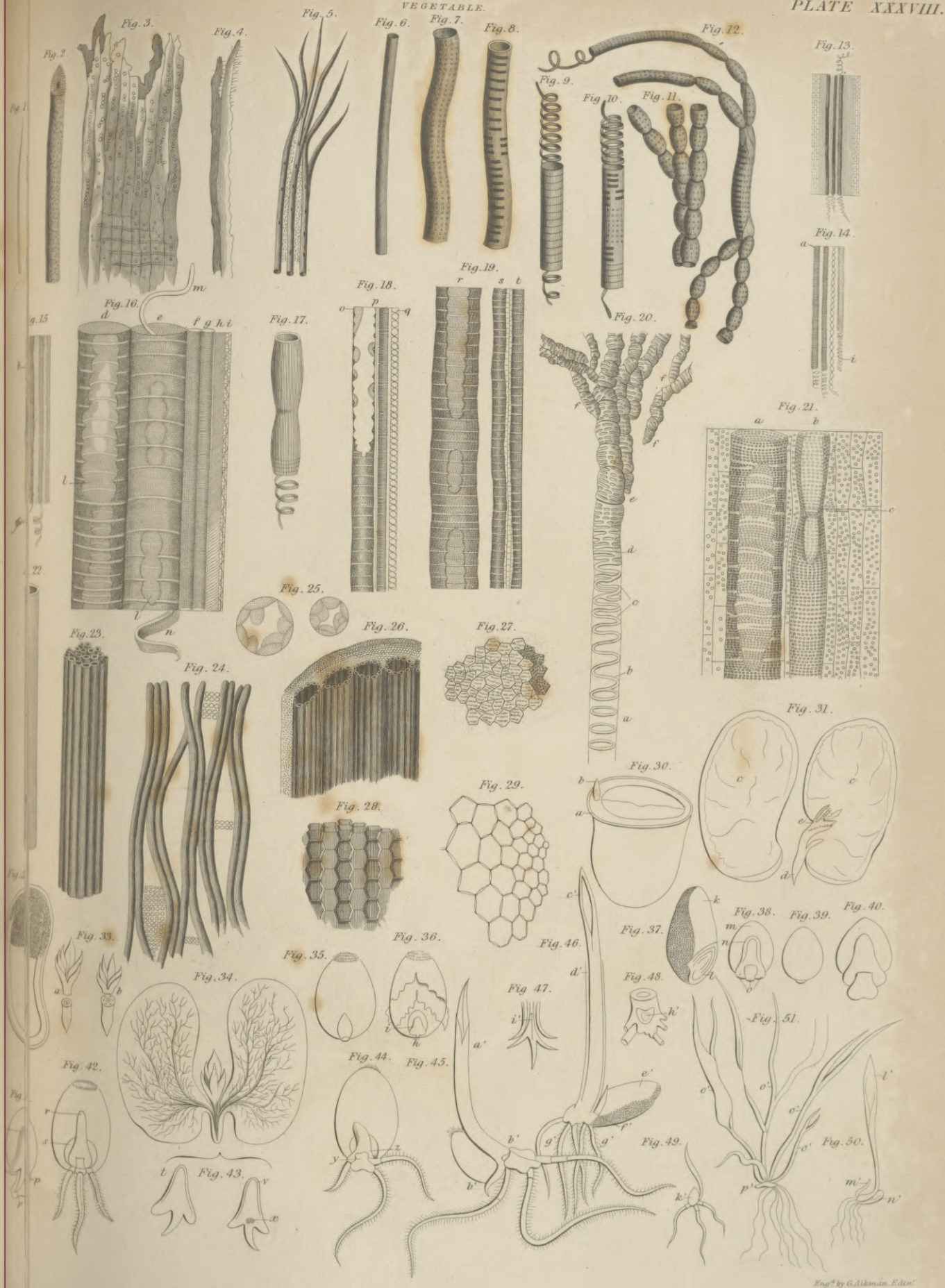
PLATE XXXVII.

Engd by G. Aikman, Edinr.

ANATOMY.

VEGETABLE.

PLATE XXXVIII.

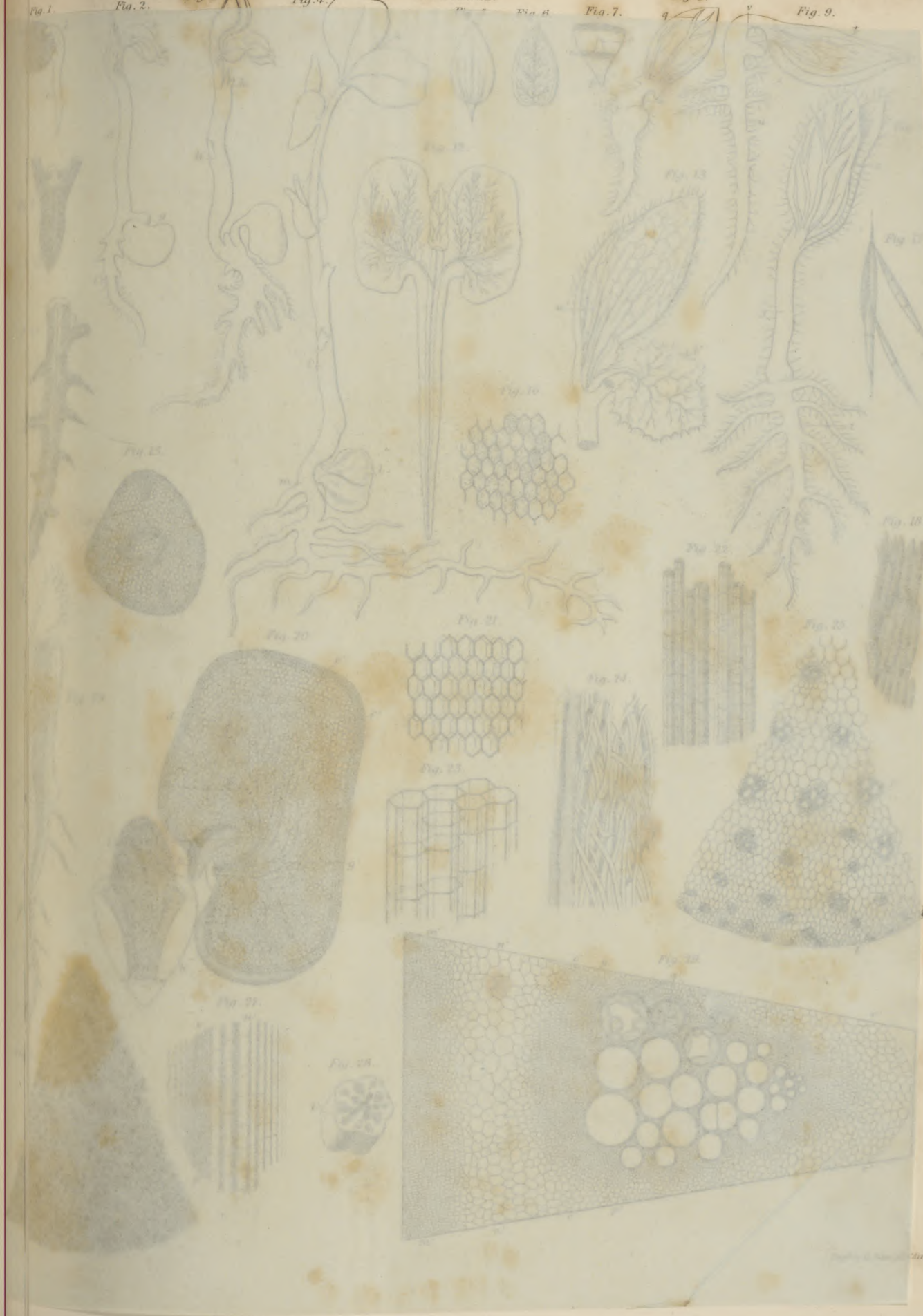


Engd by G. Aikman. Edin.

ANATOMY.

VEGETABLE.

PLATE XXXIX



ANATOMY.

VEGETABLE.

PLATE XXXIX.

Engd by G. Atkman, Edin.

k
l
A
a'
c'
a'
a'

ANATOMY.

VEGETABLE.

PLATE XL.

Engd by G Aikman. Edinr

Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 12
Fig. 13
Fig. 14
Fig. 15
Fig. 16
Fig. 17
Fig. 18
Fig. 19
Fig. 20
Fig. 21
Fig. 22
Fig. 23

ANATOMY.

VEGETABLE.

PLATE XLI.

ANATOMY.

VEGETABLE.

PLATE XLII.

ANATOMY.

VEGETABLE.

PLATE XLII.

Engd by G. Aikman, Edinr.

Common Anchor.

Fig. 1.

Fig. 2.

Fig. 7.

Section through Shank

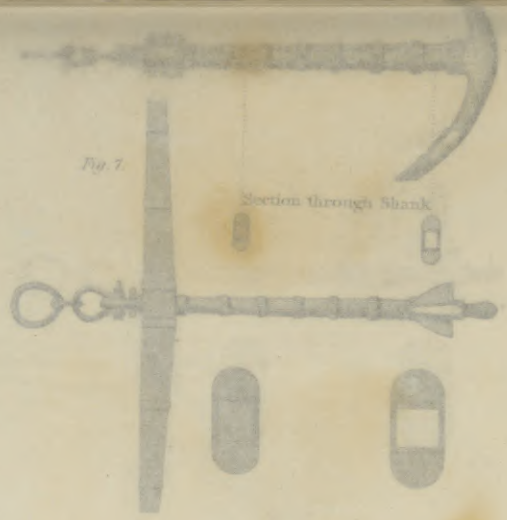


Fig. 4.

Fig. 3.

New Mooring Anchor.

Fig. 5.

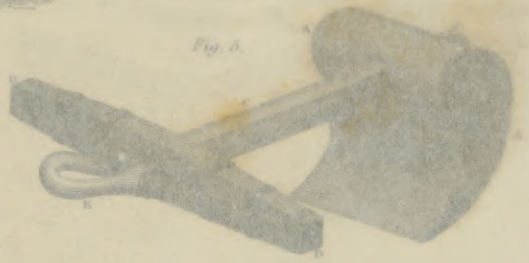
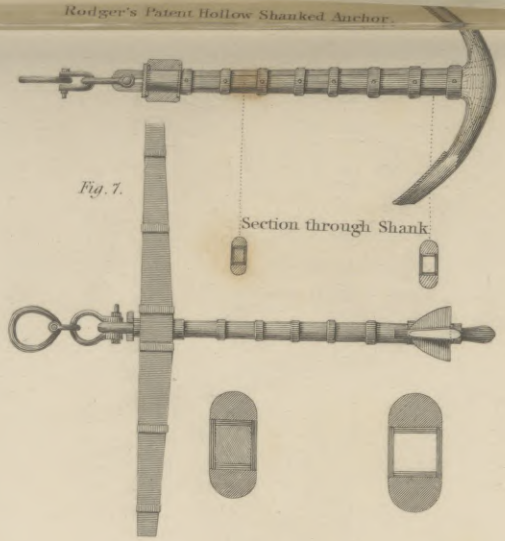


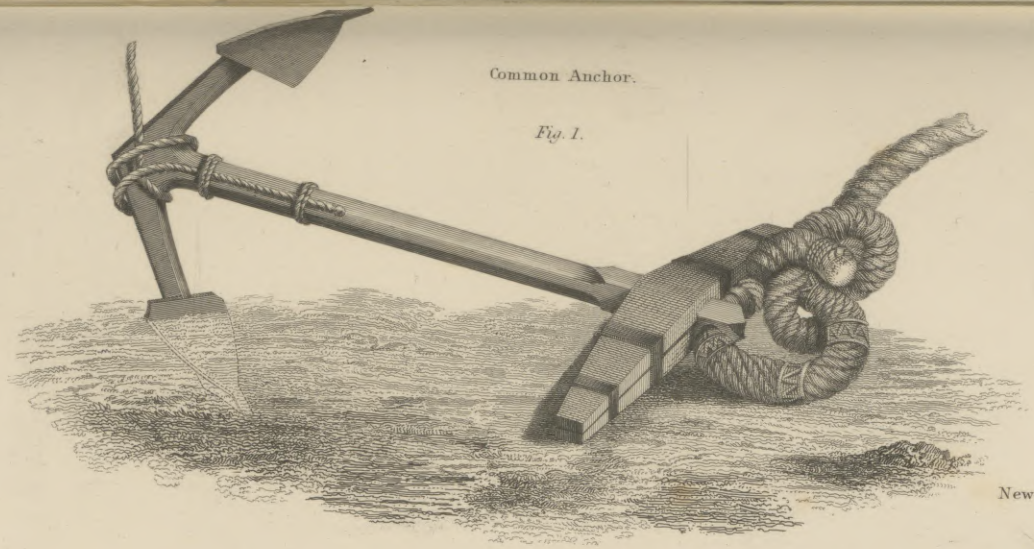
Fig. 6.

Anchor Smith's Shop.

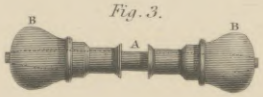
Rodger's Patent Hollow Shanked Anchor.



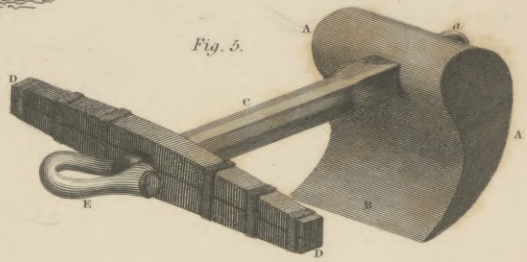
Common Anchor.



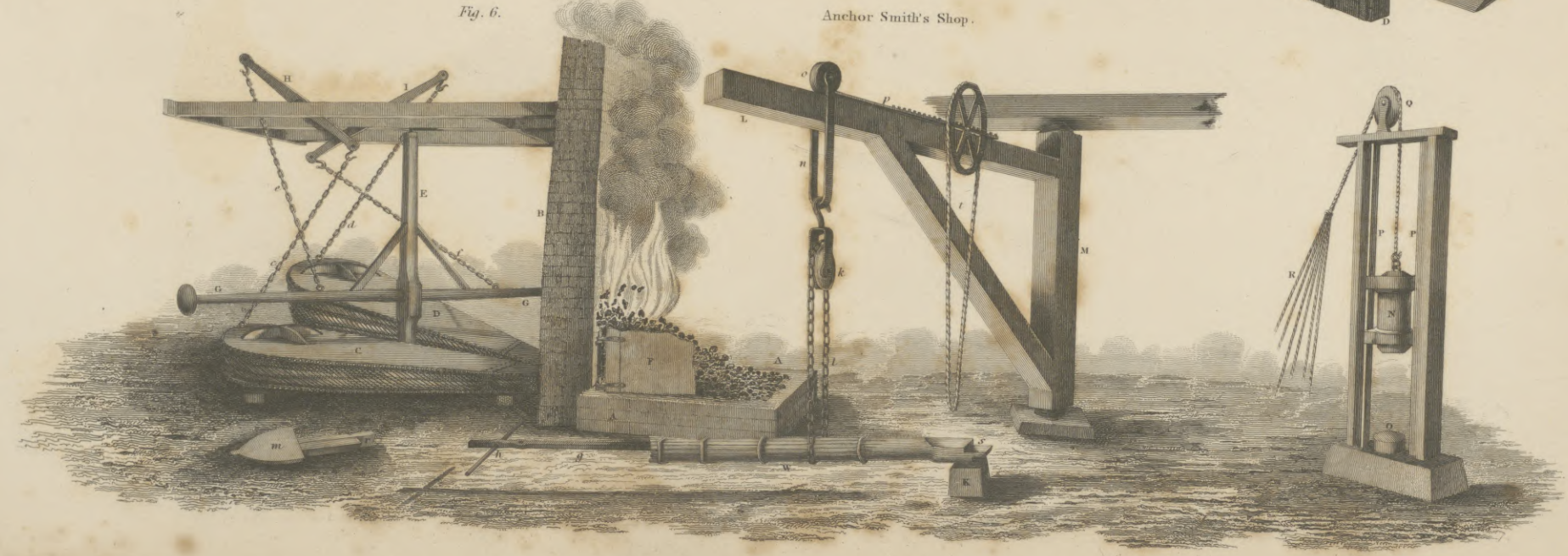
Mr Stuard's Anchor.



New Mooring Anchor.

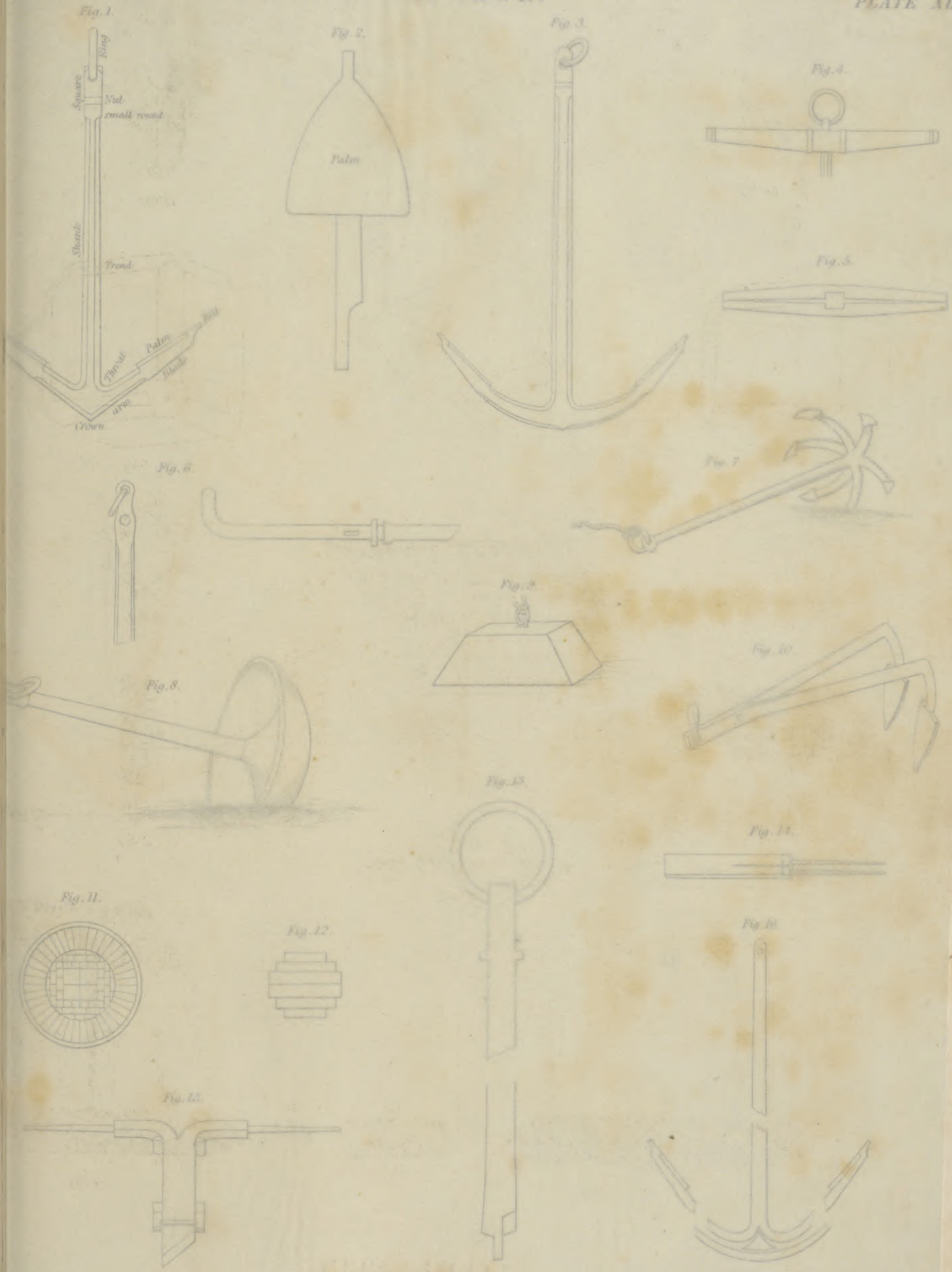


Anchor Smith's Shop.



ANCHOR.

PLATE XLIV



ANCHOR.

Fig. 1.

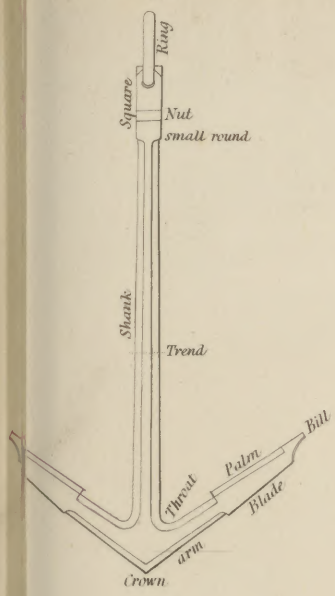
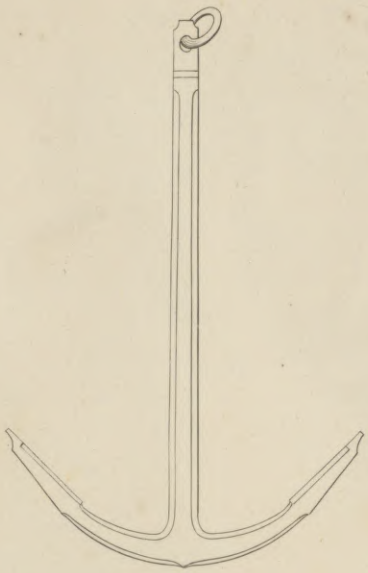


Fig. 2.

Fig. 3.



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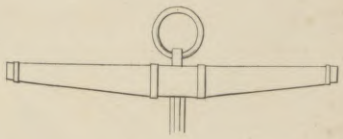

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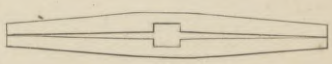

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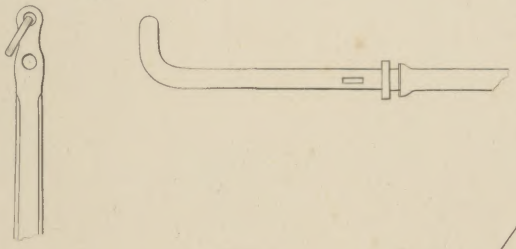

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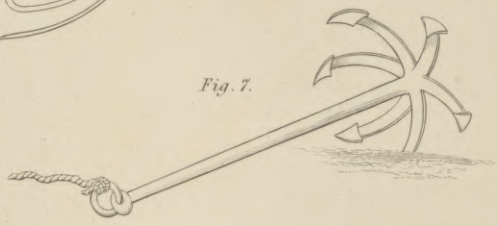

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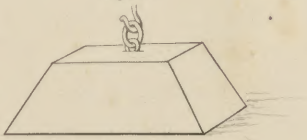

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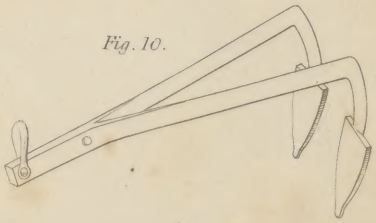
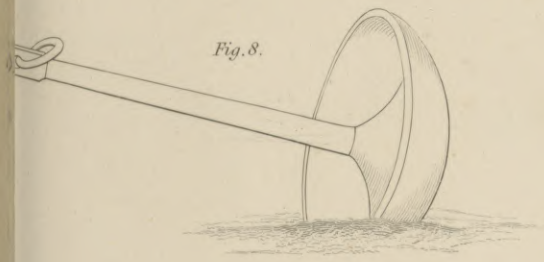


Fig. 8.



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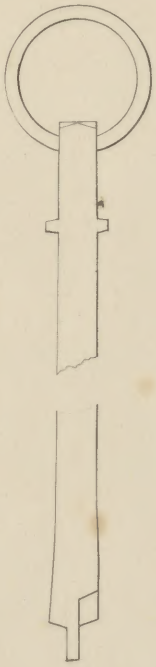

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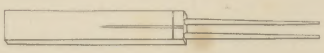

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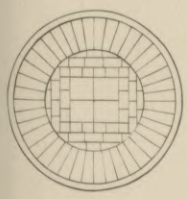

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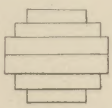

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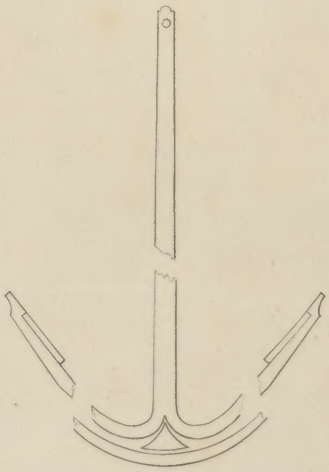

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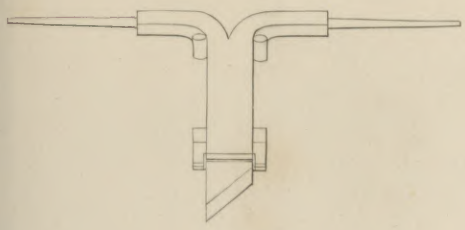

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Fig. 1.
Fig. 4.
Fig. 5.
Fig. 8.
Fig. 9.
Fig. 14.
Fig. 21.
Fig. 24.

ANGLING.

PLATE XLV

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ANIMALCULES.

PLATE XLVI.

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Fig. 25.
Fig. 26.
Fig. 27.
Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31.
Fig. 32.
Fig. 33.
Fig. 34.
Fig. 35.
Fig. 36.
Fig. 37.
Fig. 38.
Fig. 39.
Fig. 40.
Fig. 41.
Fig. 42.
Fig. 43.
Fig. 44.
Fig. 45.
Fig. 46.
Fig. 47.
Fig. 48.

ANIMALCULES.

PLATE XLVII.

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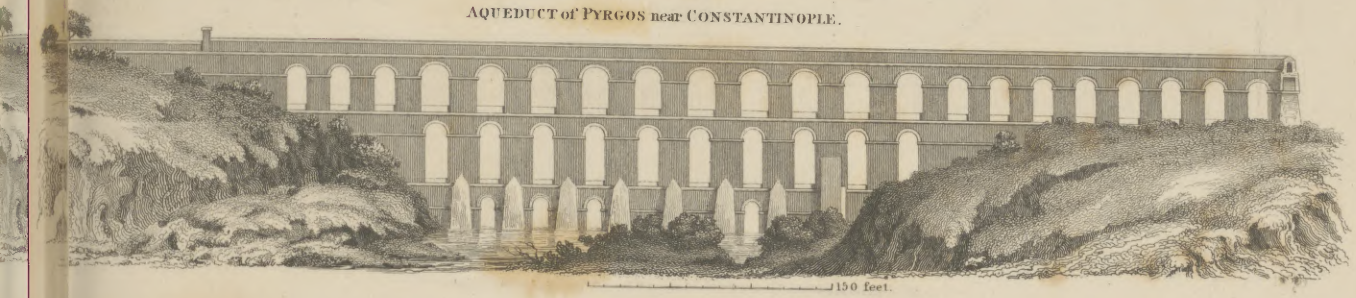
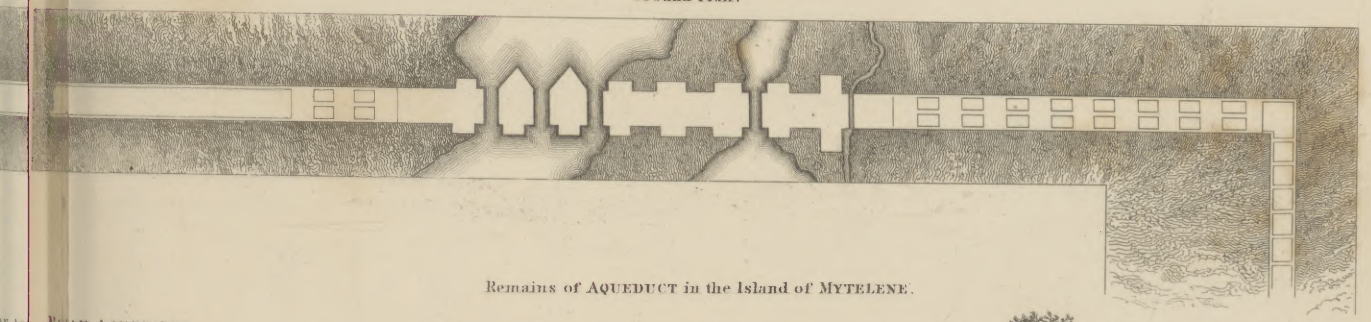
AQUEDUCT.

Remains of AQUEDUCT near ANTIOCH.

AQUEDUCT of PYRGOS near CONSTANTINOPLE.

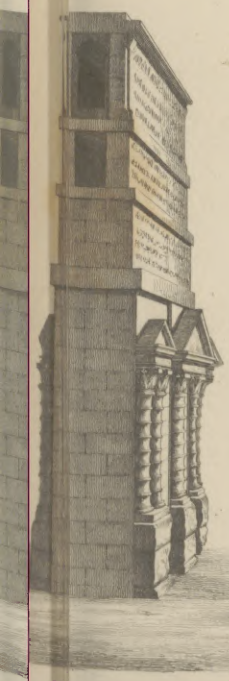


Ground Plan.

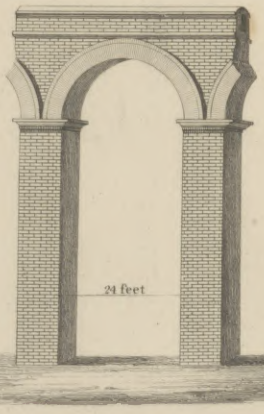


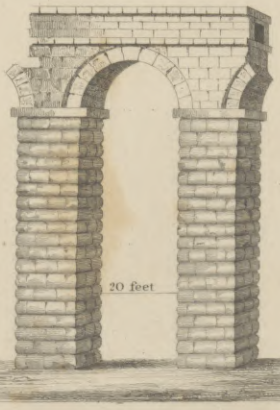
Remains of AQUEDUCT in the Island of MYTELENE.

ROMAN AQUEDUCT.



ROMAN AQUEDUCTS





ROMAN AQUEDUCT.

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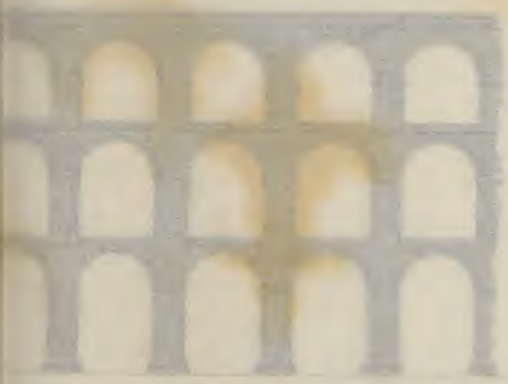
AQUEDUCT.

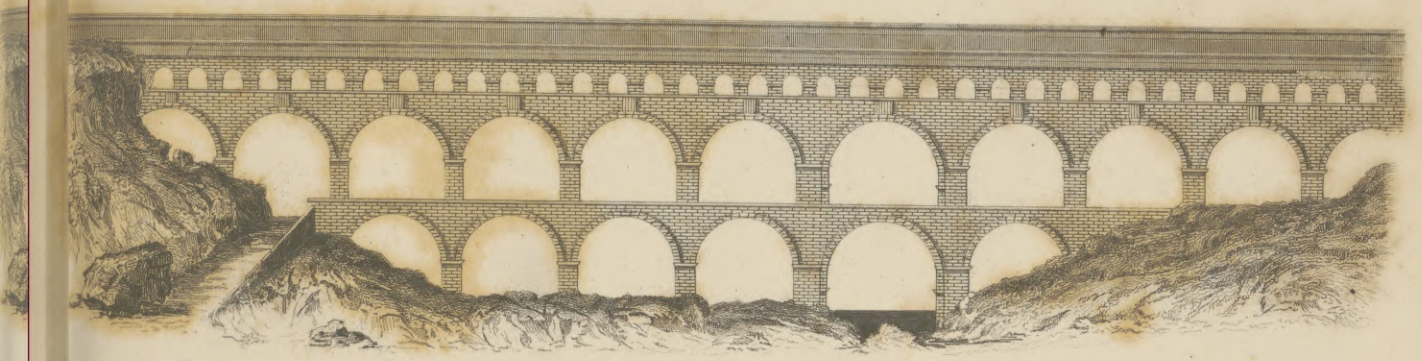


AQUEDUCT.

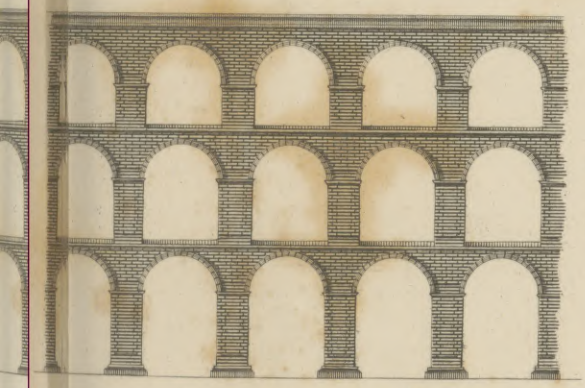
PLATE XLIX.

Remains of AQUEDUCT of METZ.

AQUEDUCT or PONT du GARD near NISMES.



AQUEDUCT of MAINTENON.

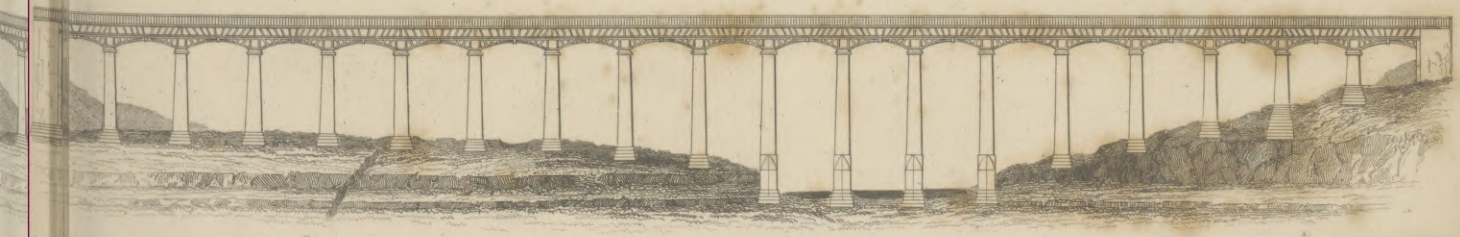


Scale to all the Aqueducts on Plate.

AQUEDUCT of SLATEFORD near EDINBURGH.

CHIRK AQUEDUCT.

PONT CYSYLTE AQUEDUCT.



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Epeira diadema
Lycosa tarentula

ARACHNIDES.

PLATE L

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Nymphon grossipes
Siro rubens
Ammothea carolinensis
young
Acarus passerinus
Bdella longicornis
Smaridia passerina
magnified
Hydrachna cruenta
Ixodes reduvius
Argas reflexus
Eylais extendens
magnified
Leptus autumnalis
Astoma parasitica
Hydrachna geographica

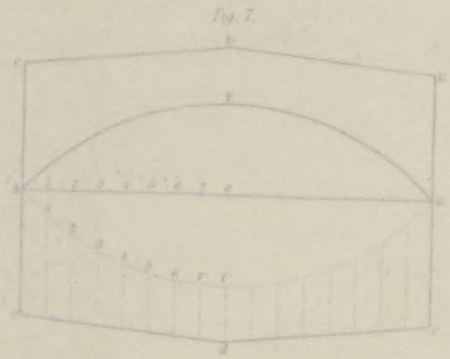
ARACHNIDES.

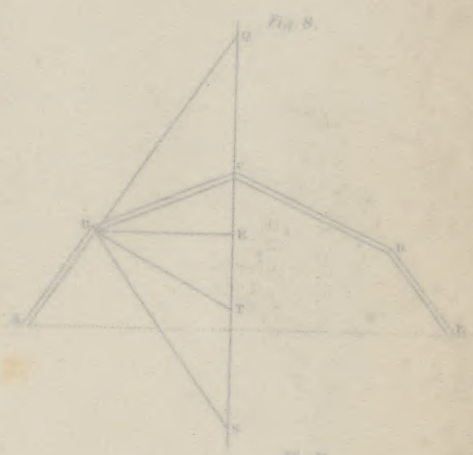
PLATE LI.

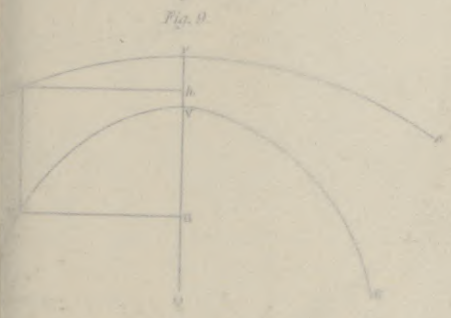
Engd by G. Aikman, Edinr

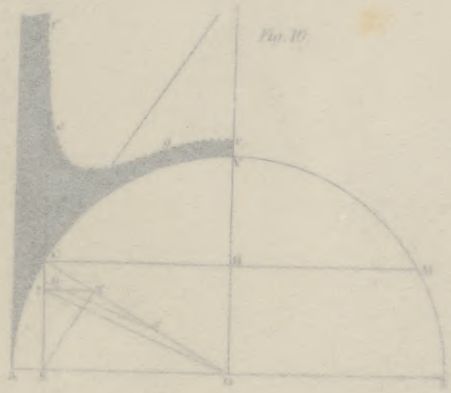
ARCH.

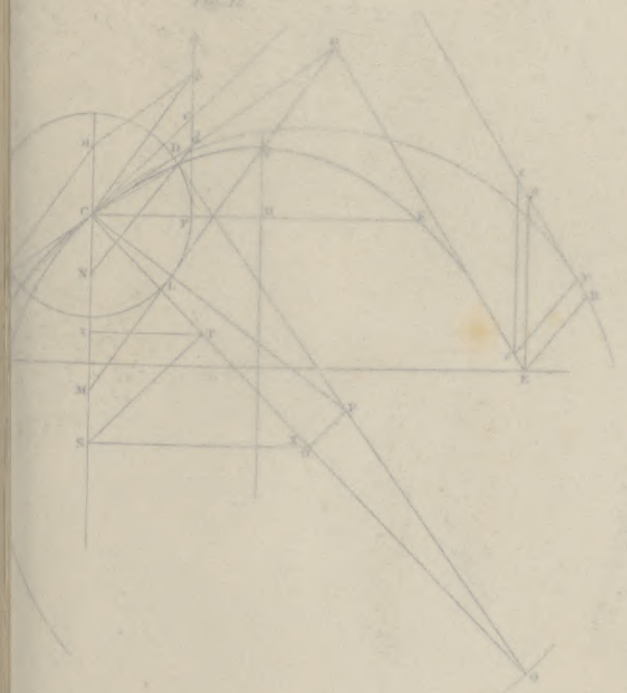
PLATE LII.



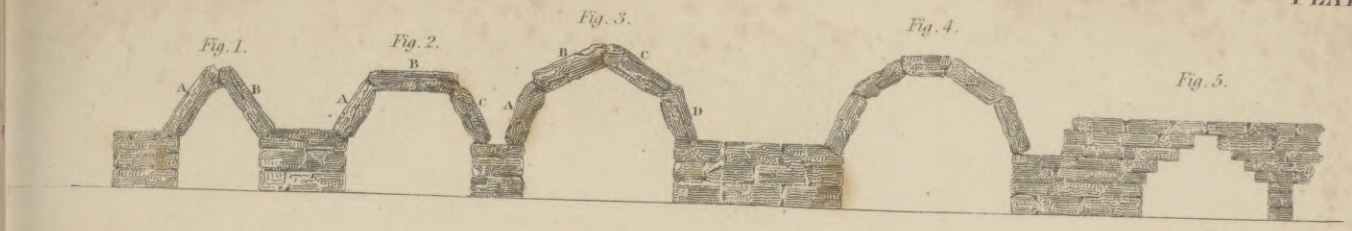


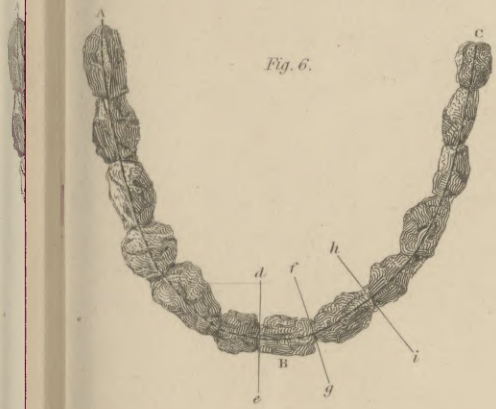


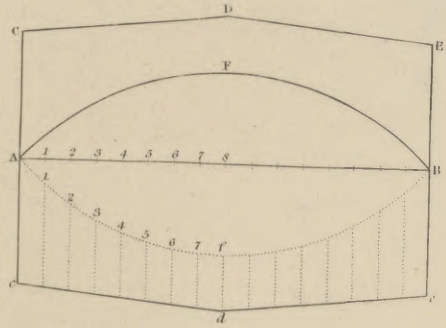


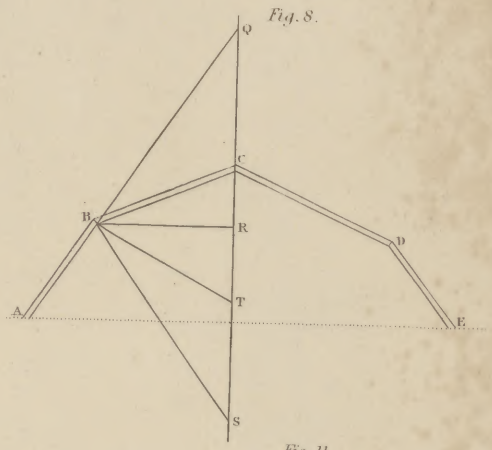


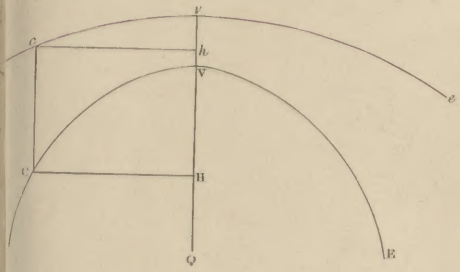
ARCH.

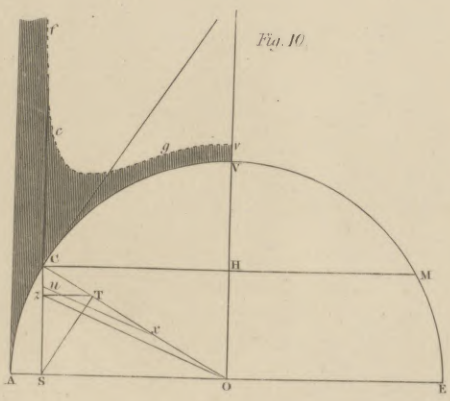


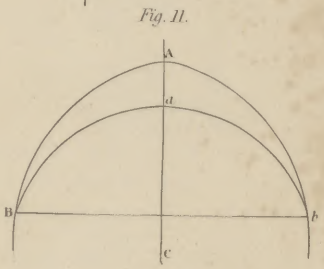


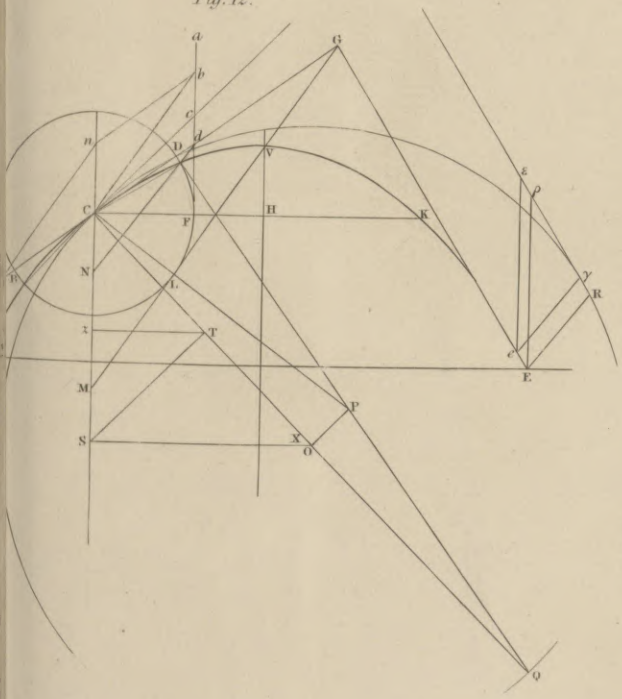


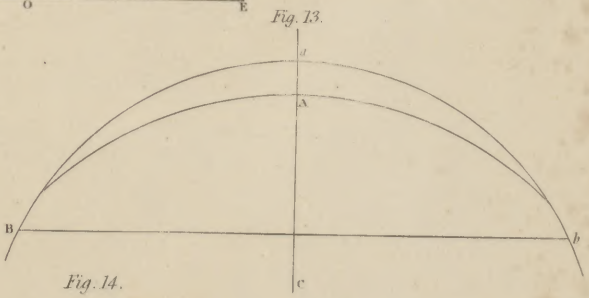


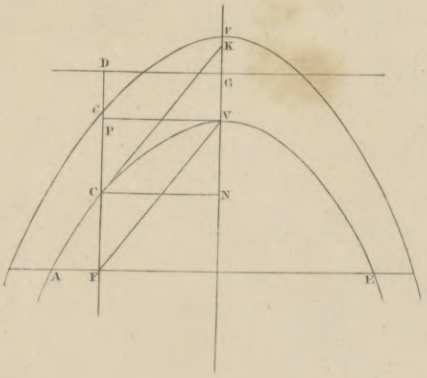


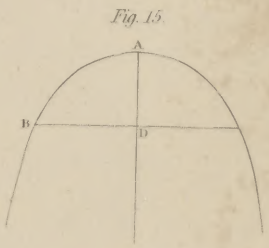












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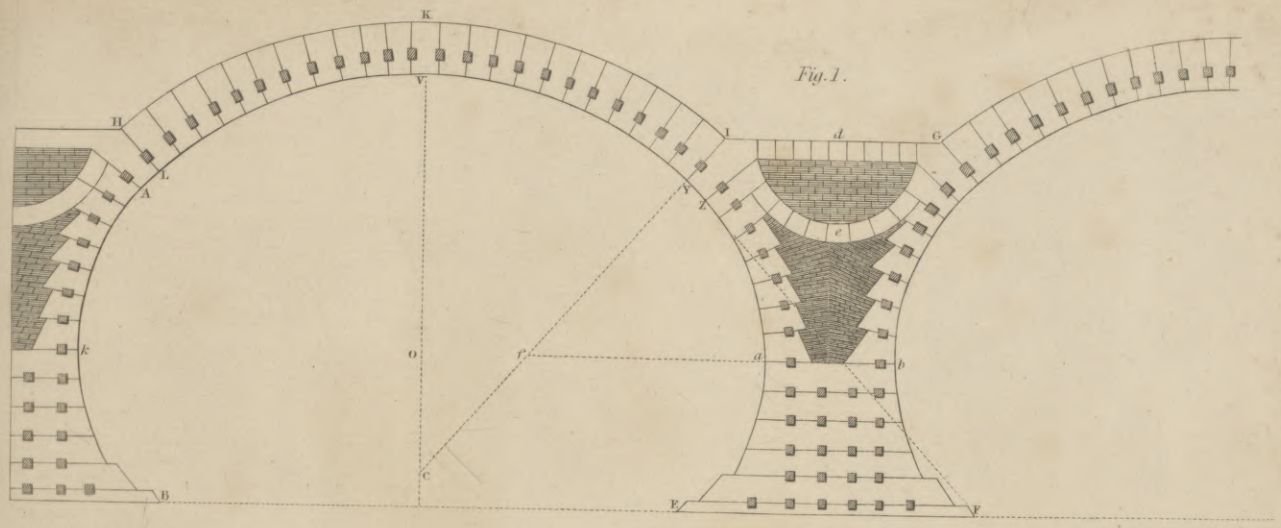
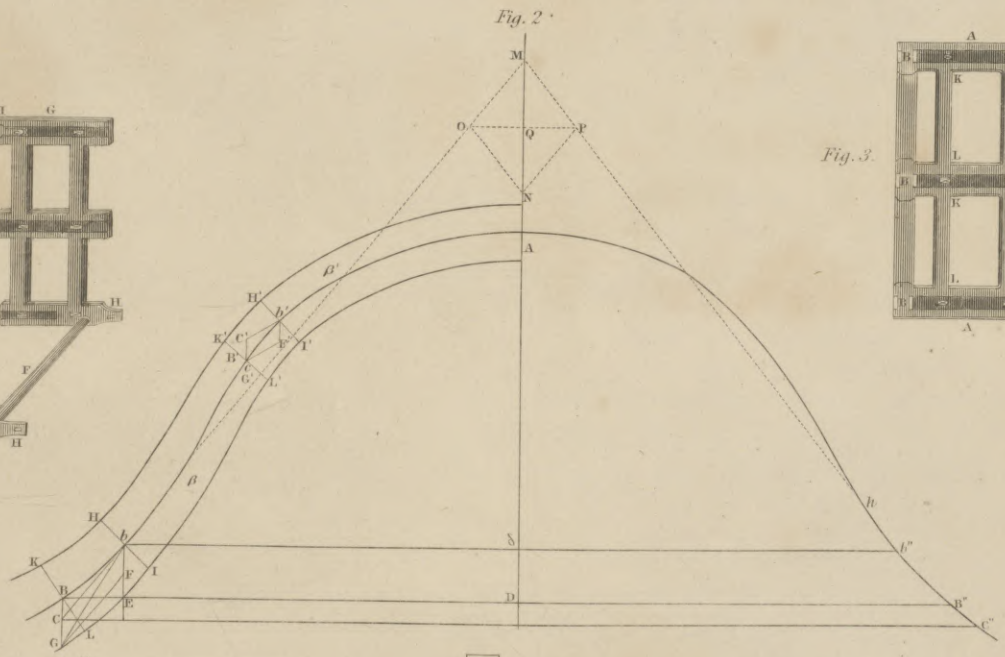
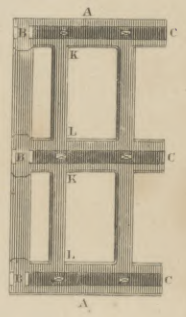
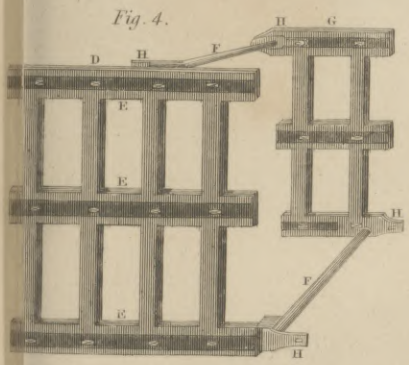
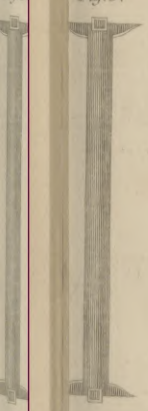
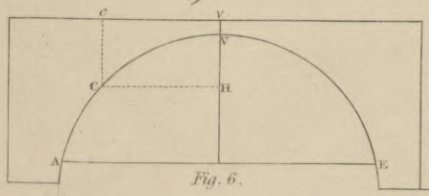


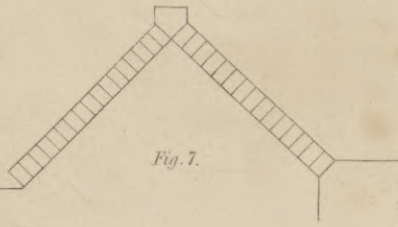


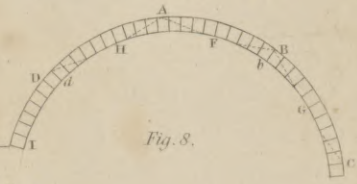


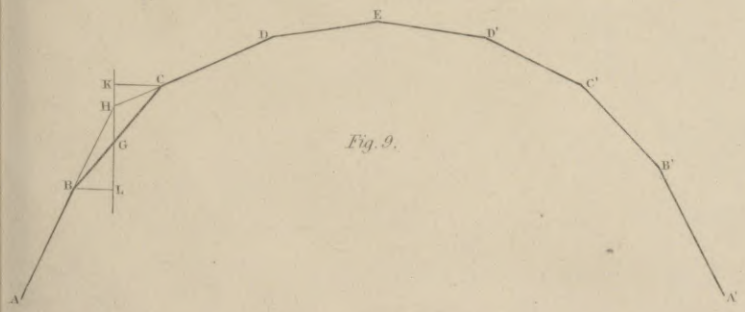


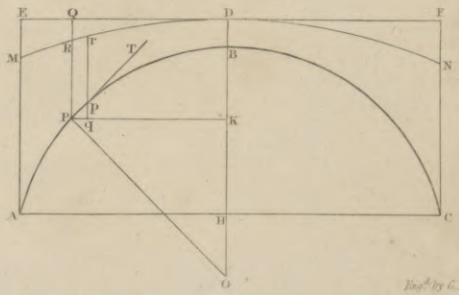












Engd. by G. Aikman, Edin.

The Temple of Minerva Parthenon at Athens.
(North-west view.)

In its present state.

Restored

W. Jenkins Esq.r Arch.t Del.t

Eng.d by W. Howison Edin.r

Fig. 1.

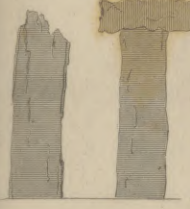
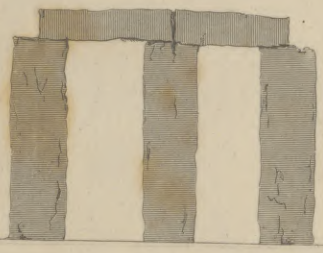


Fig. 2.

Fig. 3.

Fig. 4.



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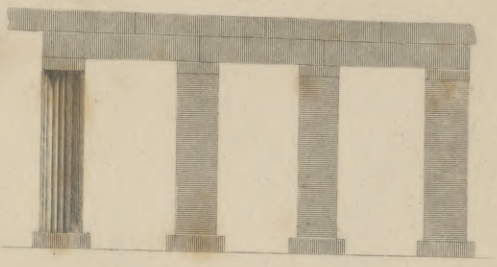


Fig. 6.

Fig. 7.

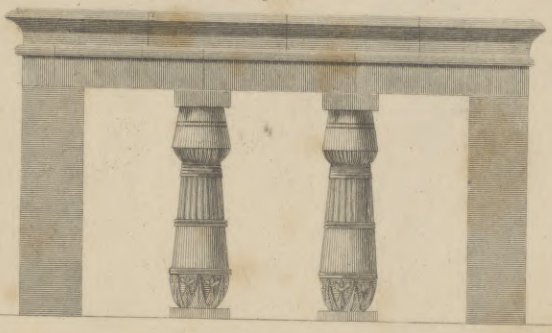


Fig. 8.

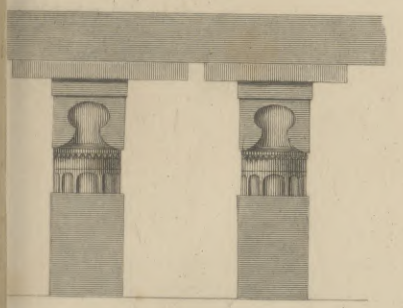


Fig. 9.

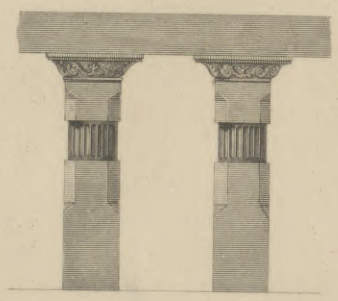


Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

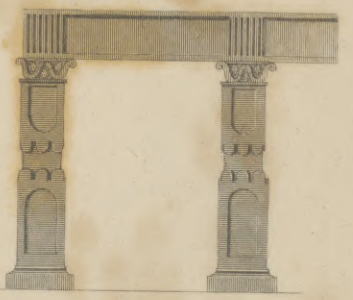


Fig. 14.

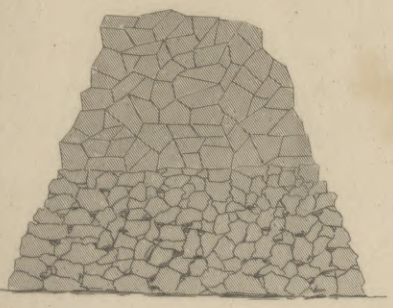


Fig. 15.

Fig. 16.

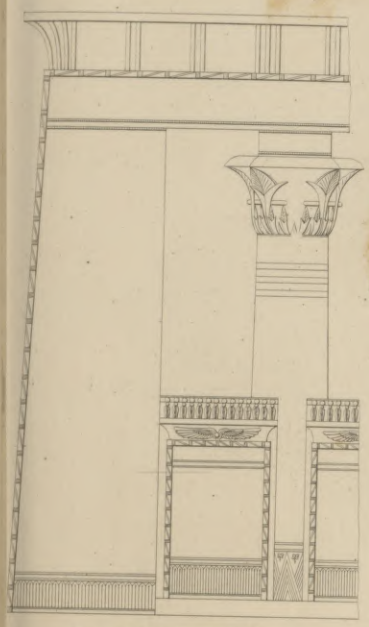
Engd. by G. Aikman, Edinr.

Plan, Section and Elevations of the Temple of Apollinopolis Magna in Upper Egypt.

Fig. 1.

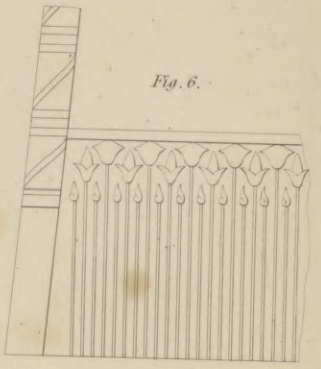
Elevation of Propylæa.

Fig. 5.



Part of Elevation of Pronaos at an enlarged scale.

Fig. 6.



Angle torus & lotus enrichment to Propylæa at an enlarged scale.

Fig. 2.

Elevation of Pronaos.
(Section on the line B.B. of Plan.)

Fig. 7.

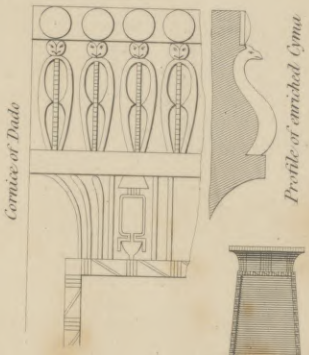
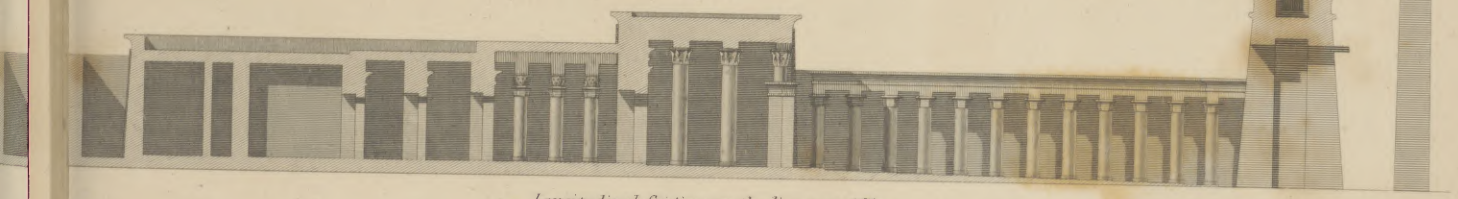
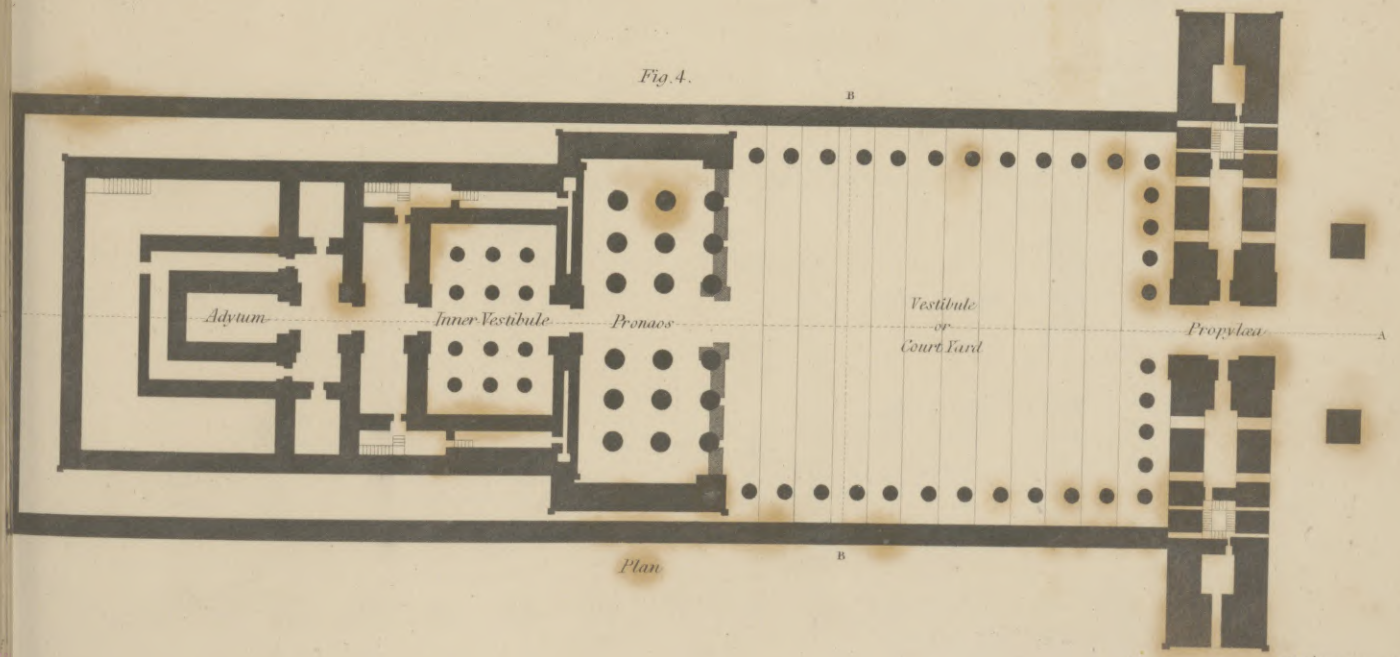


Fig. 3.



Longitudinal Section on the line A.A. of Plan.

Fig. 4.



Plan

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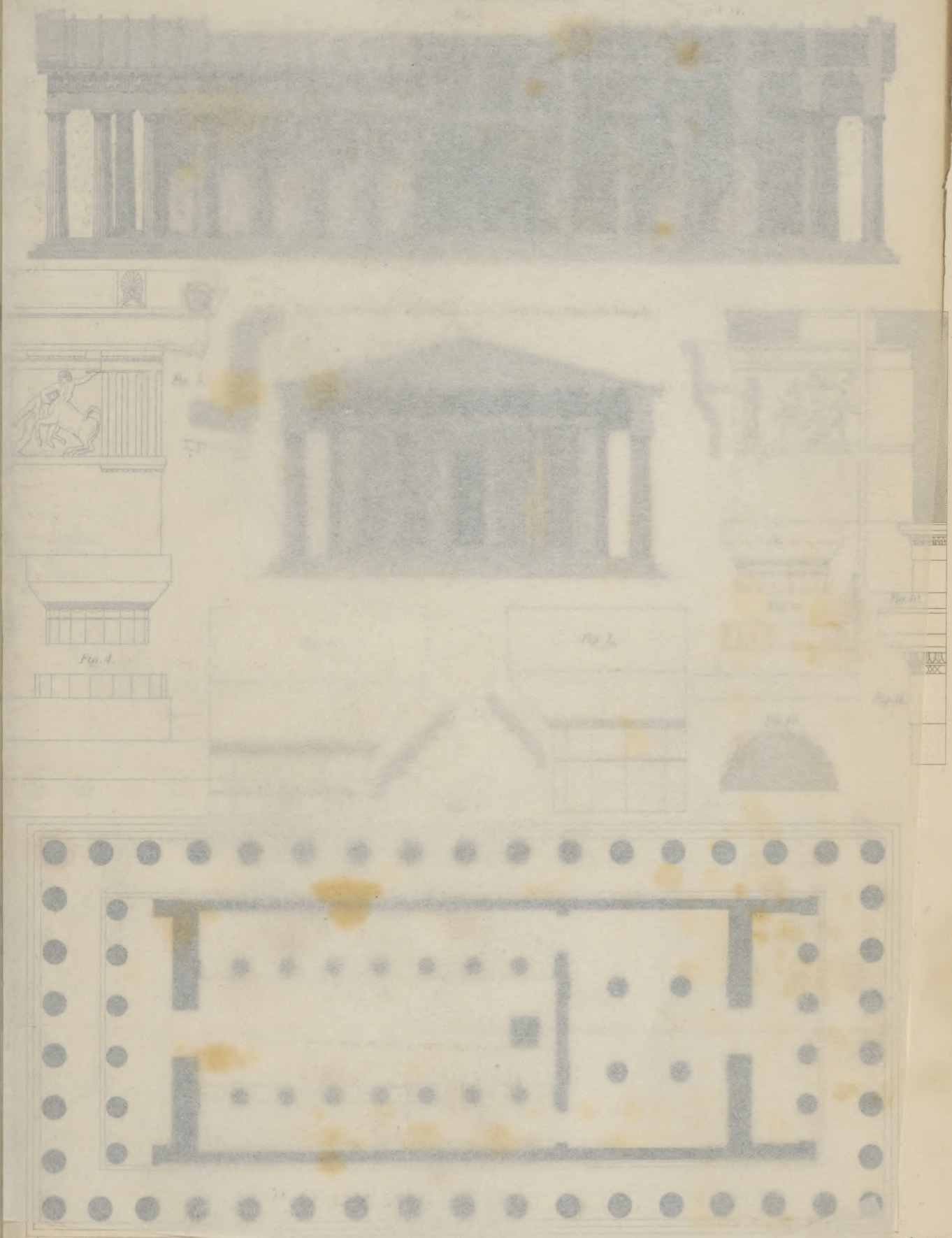
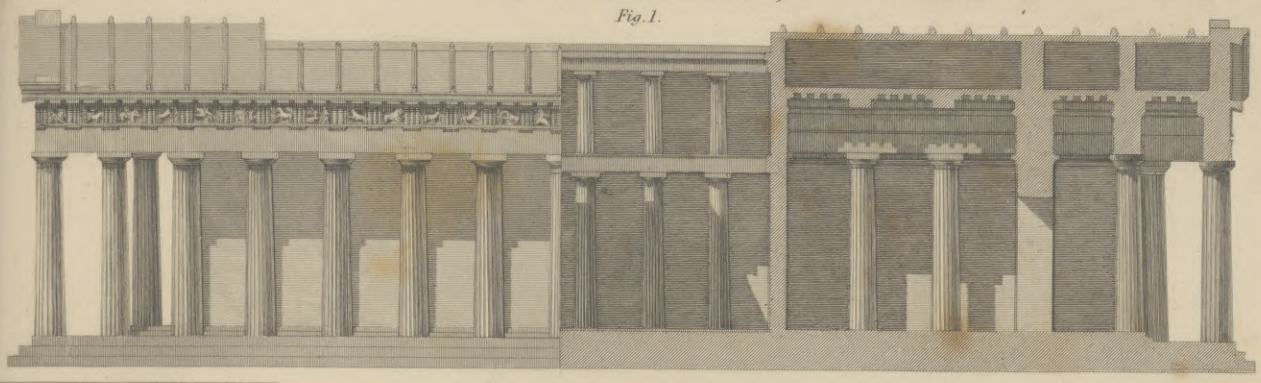
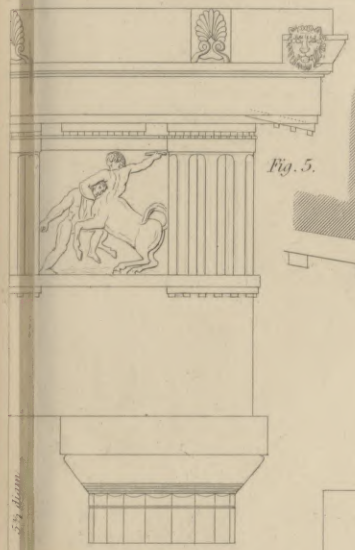


Plan of a Greek [illegible] Hypothral Temple

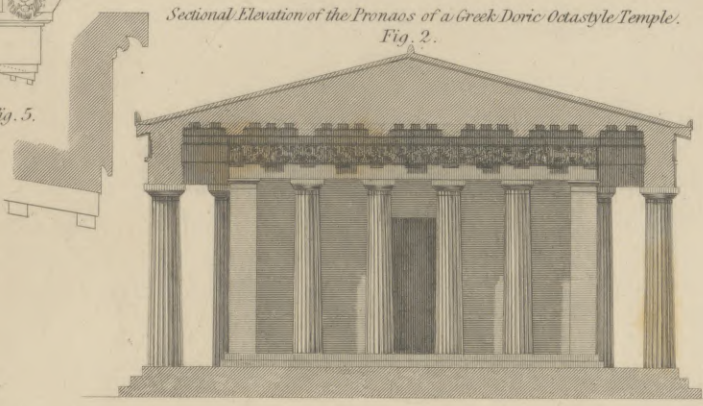
Engd by G. Aikman, Edinr.

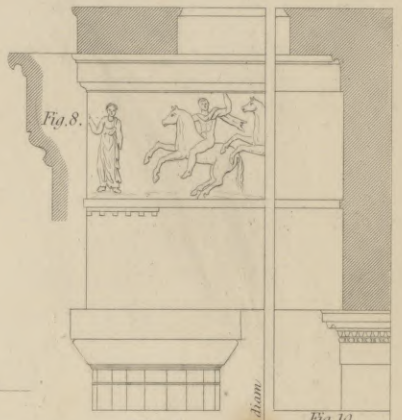
Flank & Sectional Elevation of a Greek Doric Peripteral & Hypaethral Temple.
(Section on the dotted lines of Plan below)

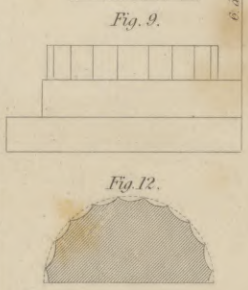


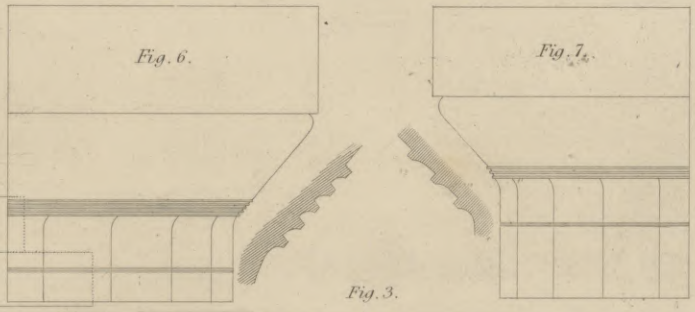


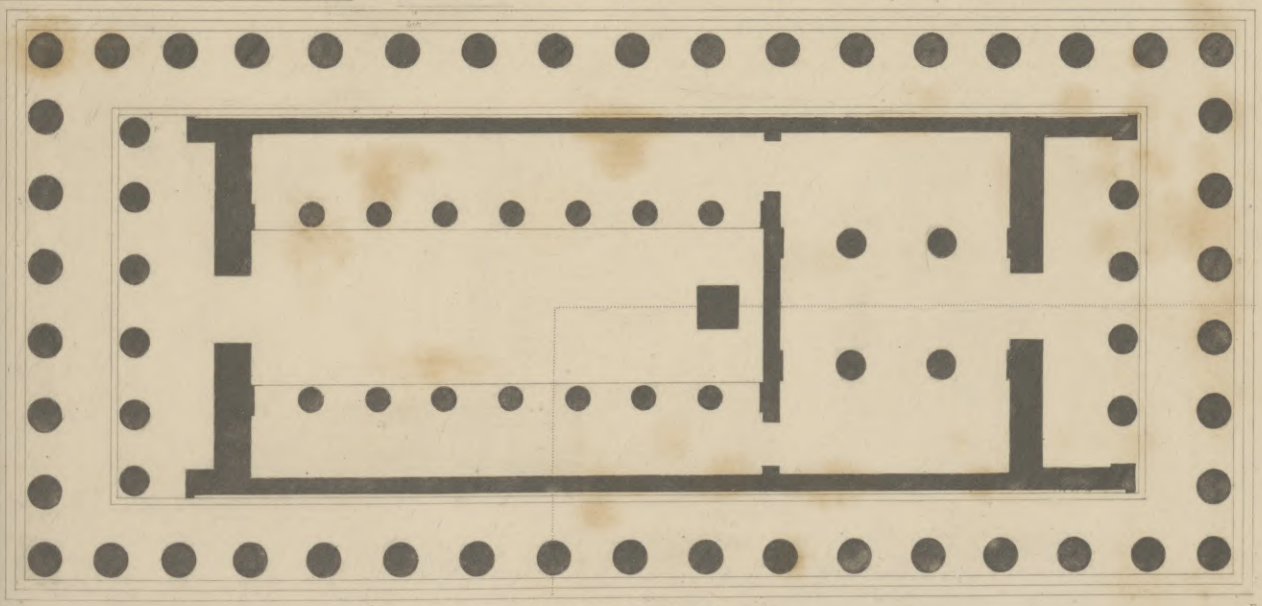
Sectional Elevation of the Pronaos of a Greek Doric Octastyle Temple.











Plan of a Greek Octastyle Peripteral & Hypaethral Temple.

Engd by G. Aikman, Edinr

ARCHITECTURE.

Fig. 1.
Front Elevation of a Greek Doric Hexastyle-peripteral Temple.

Fig. 2.
Sectional Elevation of the Pronaos of a Hexastyle-peripteral Temple.

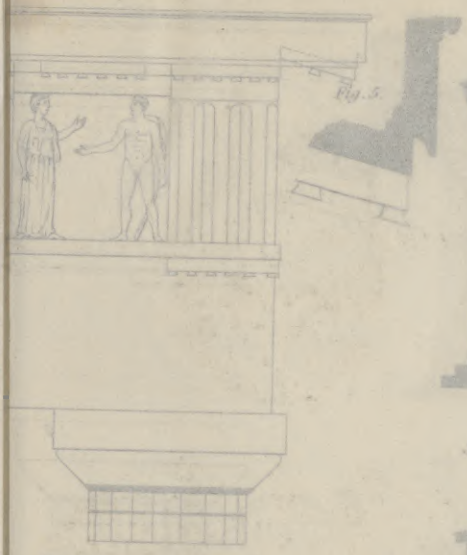


Fig. 5.

Fig. 4.

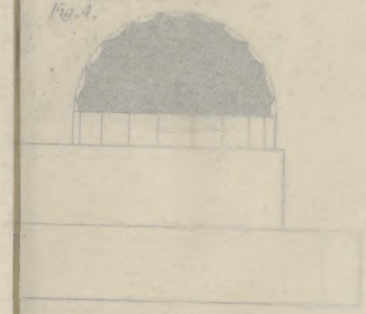


Fig. 10.

Fig. 9.

Fig. 11.

Fig. 6.

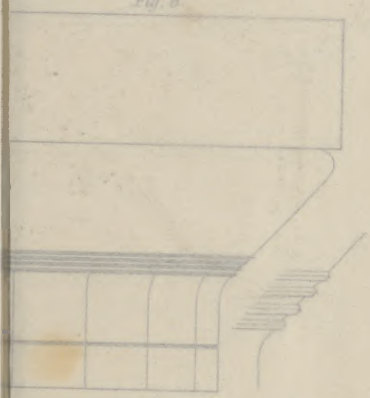


Fig. 7.

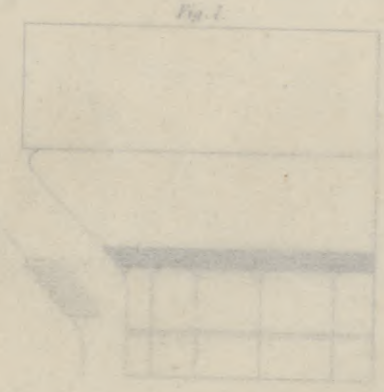


Fig. 12.

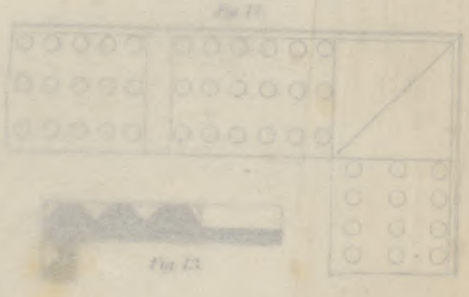
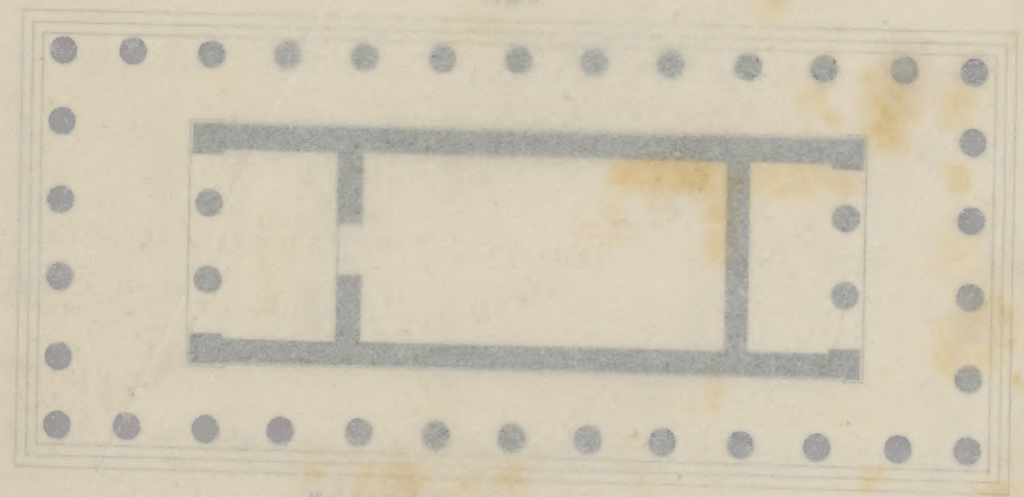


Fig. 13.

Fig. 3.



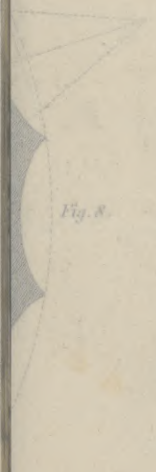


Fig. 8.

Fig. 14.

Plan of a Greek Hexastyle-peripteral & Cleithral Temple.

Engd by G. Aitken Edinr

ARCHITECTURE.

PLATE LVIII.

Fig. 1.
Front Elevation of a Greek Doric Hexastyle-peripteral Temple.

Fig. 2.
Sectional Elevation of the Pronaos of a Hexastyle-peripteral Temple.

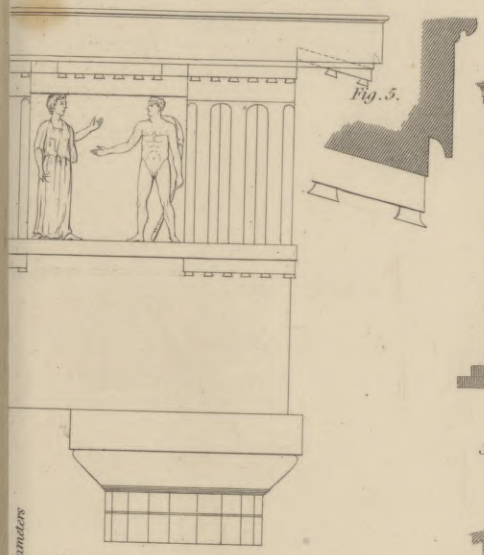


Fig. 5.

5 2/3 diameters

Fig. 4.

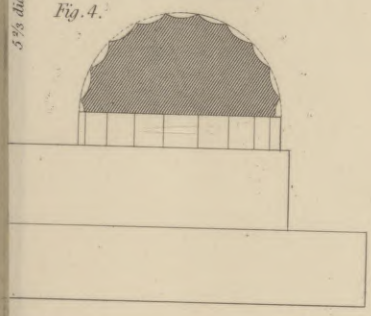


Fig. 6.

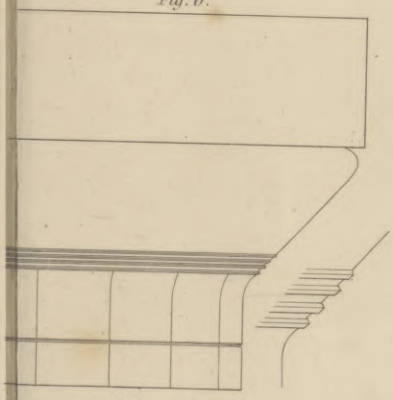
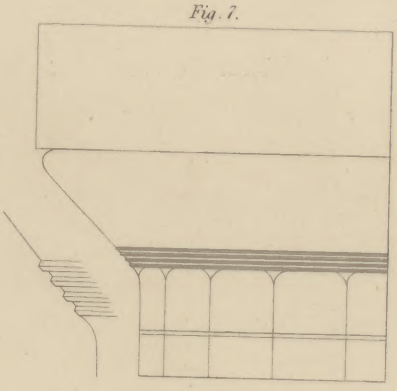


Fig. 7.



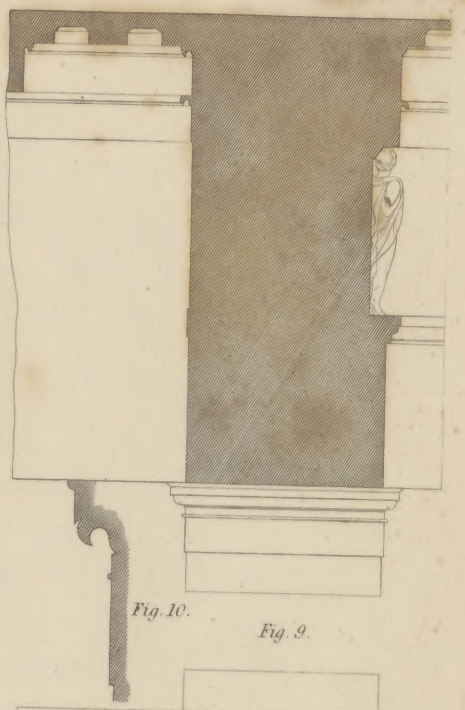


Fig. 10.

Fig. 9.

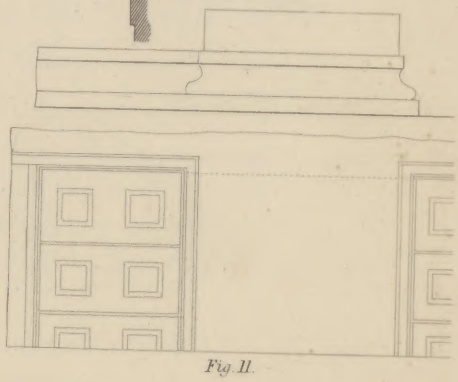


Fig. 11.

Fig. 12.

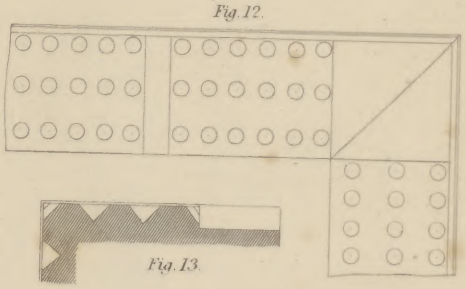
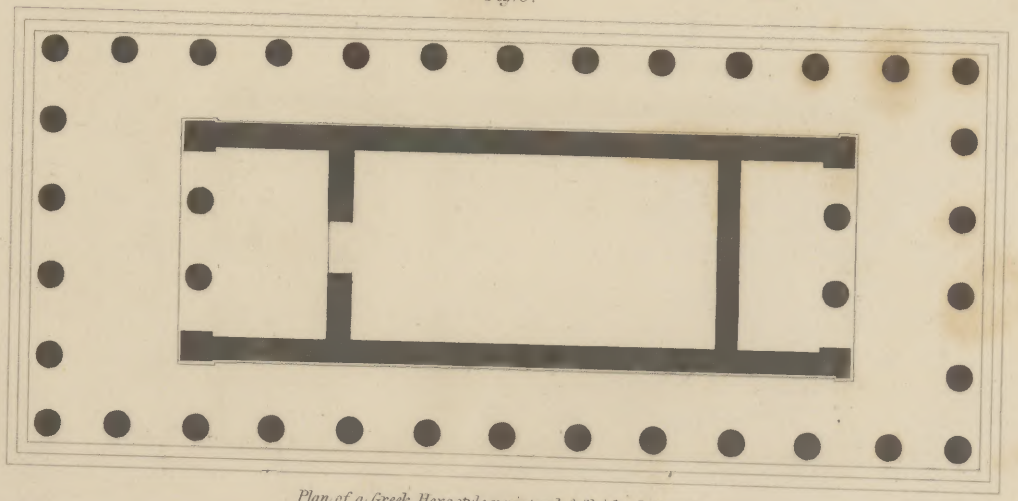


Fig. 13.

Fig. 3.



Plan of a Greek Hexastyle-peripteral & Cleithral Temple.

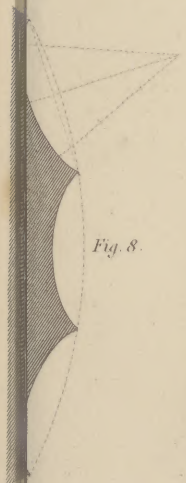


Fig. 8.

Fig. 14.

H. del.

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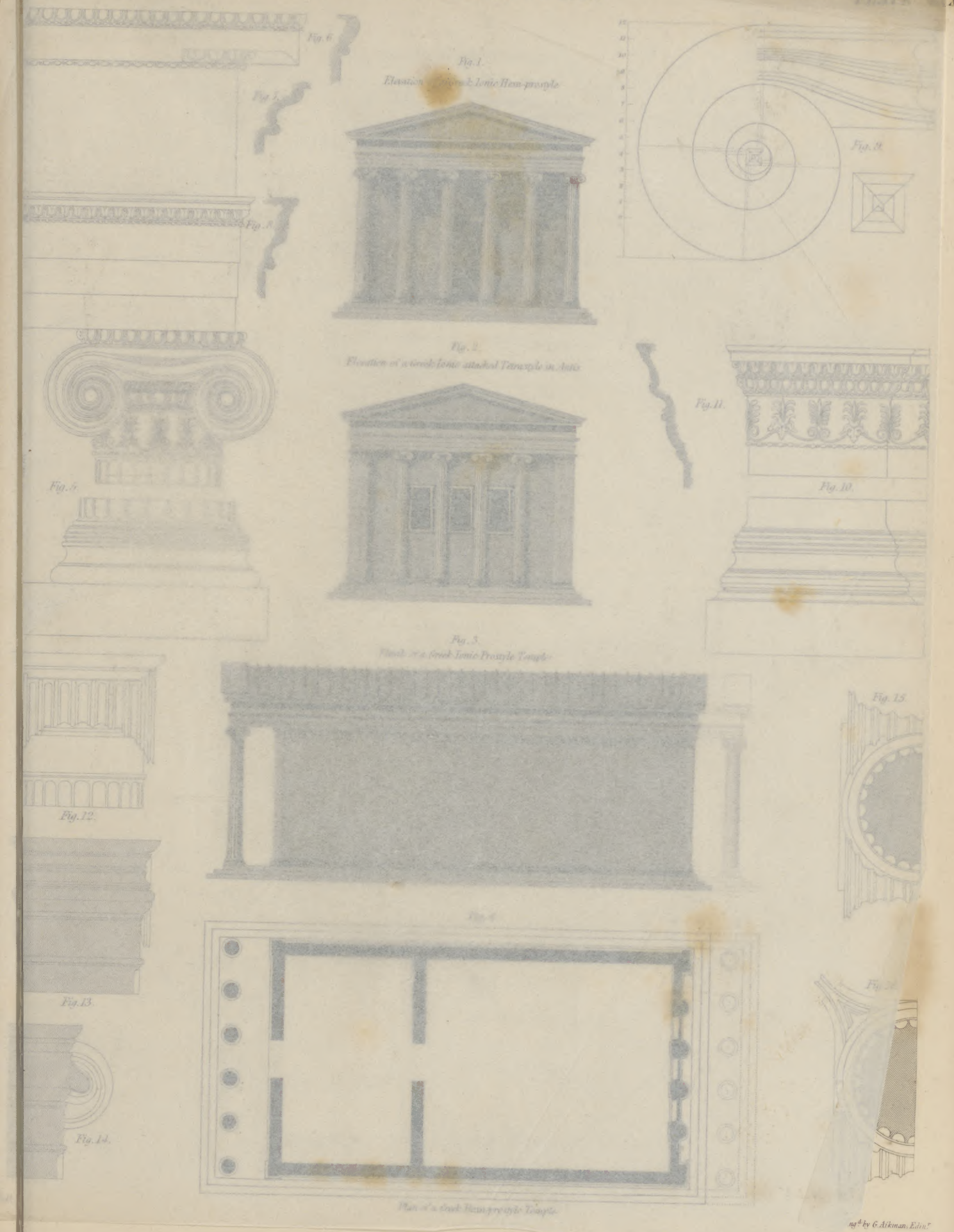


Fig. 6.
Fig. 7.
Fig. 8.
Fig. 1.
Elevation of a Greek Ionic Hem-prostyle
Fig. 9.
Fig. 2.
Elevation of a Greek Ionic attached Tetrastyle in Antis
Fig. 11.
Fig. 10.
Fig. 5.
Fig. 3.
Plan of a Greek Ionic Prostyle Temple
Fig. 12.
Fig. 15.
Fig. 13.
Fig. 14.
Fig. 4.
Plan of a Greek Hem-prostyle Temple
Engd. by G. Aikman, Edin.r

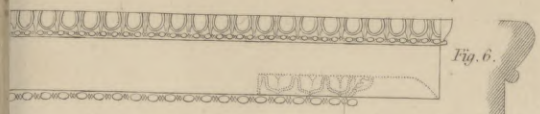


Fig. 6.

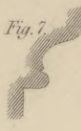


Fig. 7.

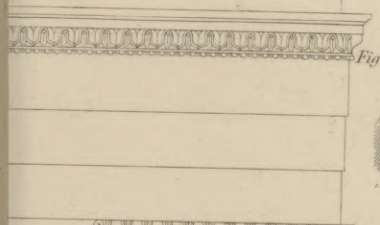


Fig. 8.

Fig. 1.
Elevation of a Greek Ionic Hexa-prostyle

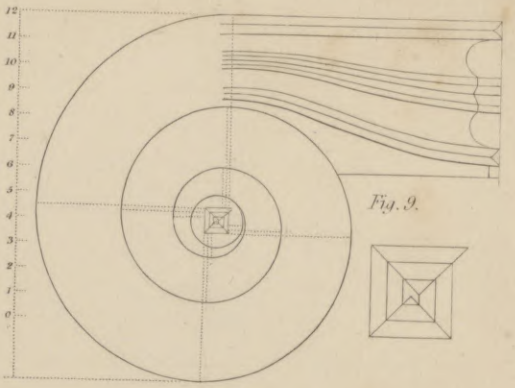
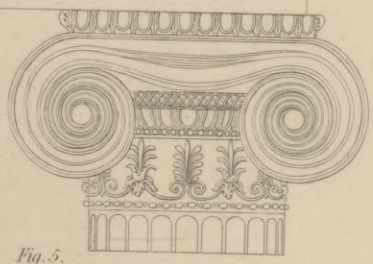


Fig. 9.



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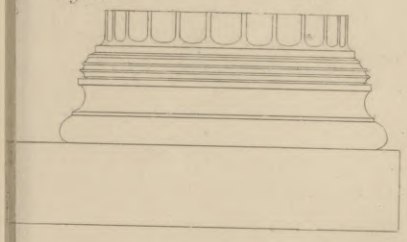


Fig. 2.
Elevation of a Greek Ionic attached Tetrastyle in Antis

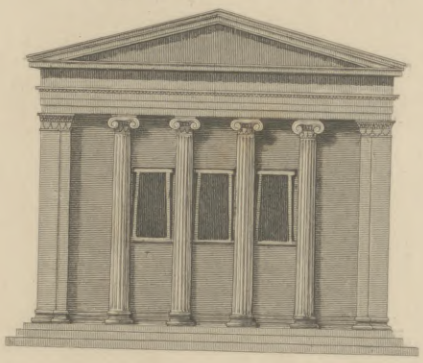


Fig. 11.

Fig. 10.

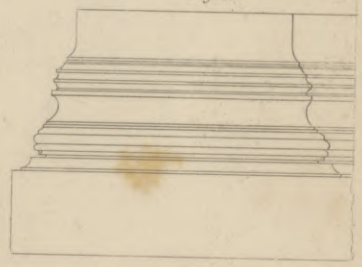
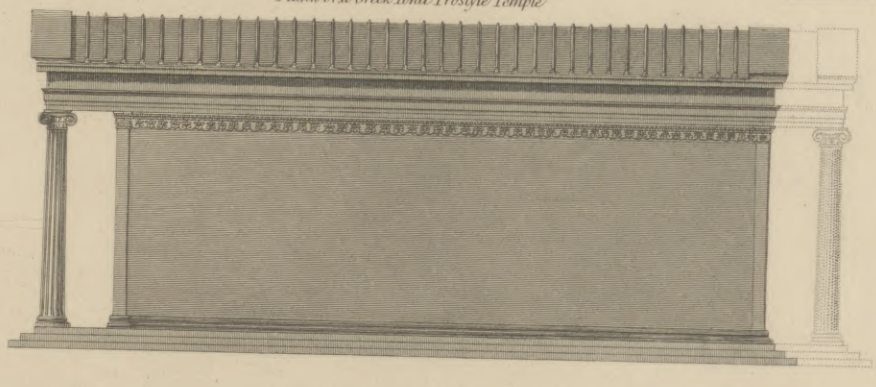
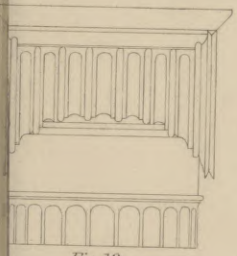


Fig. 3.
Flank of a Greek Ionic Prostyle Temple





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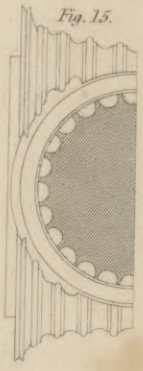

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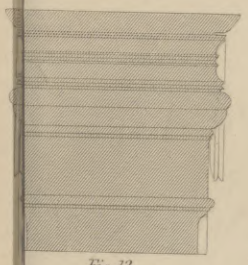
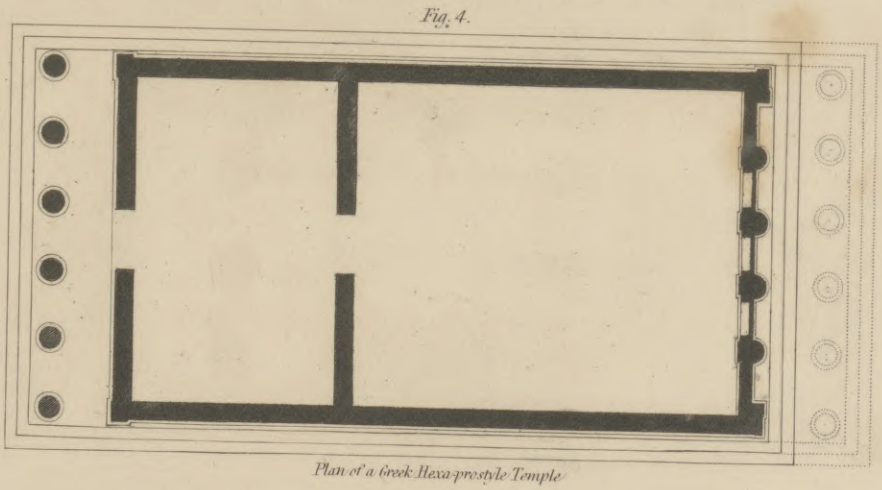


Fig. 13.

Fig. 4.



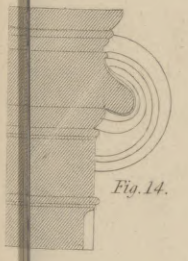


Fig. 14.

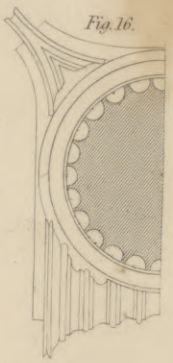


Fig. 16.

Plan of a Greek Hexa-prostyle Temple

Engd. by G. Aikman, Edinr.

Choragic Monument Greek Corinthian.

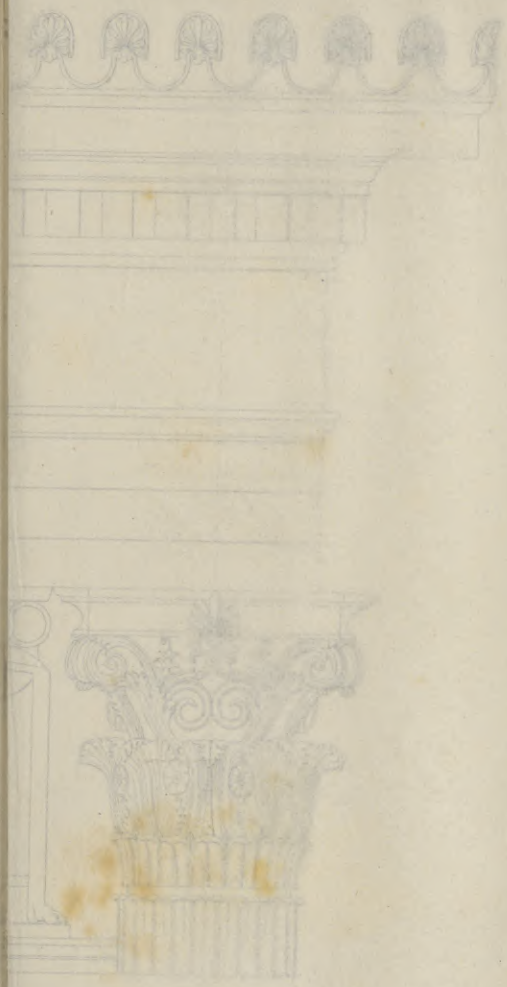
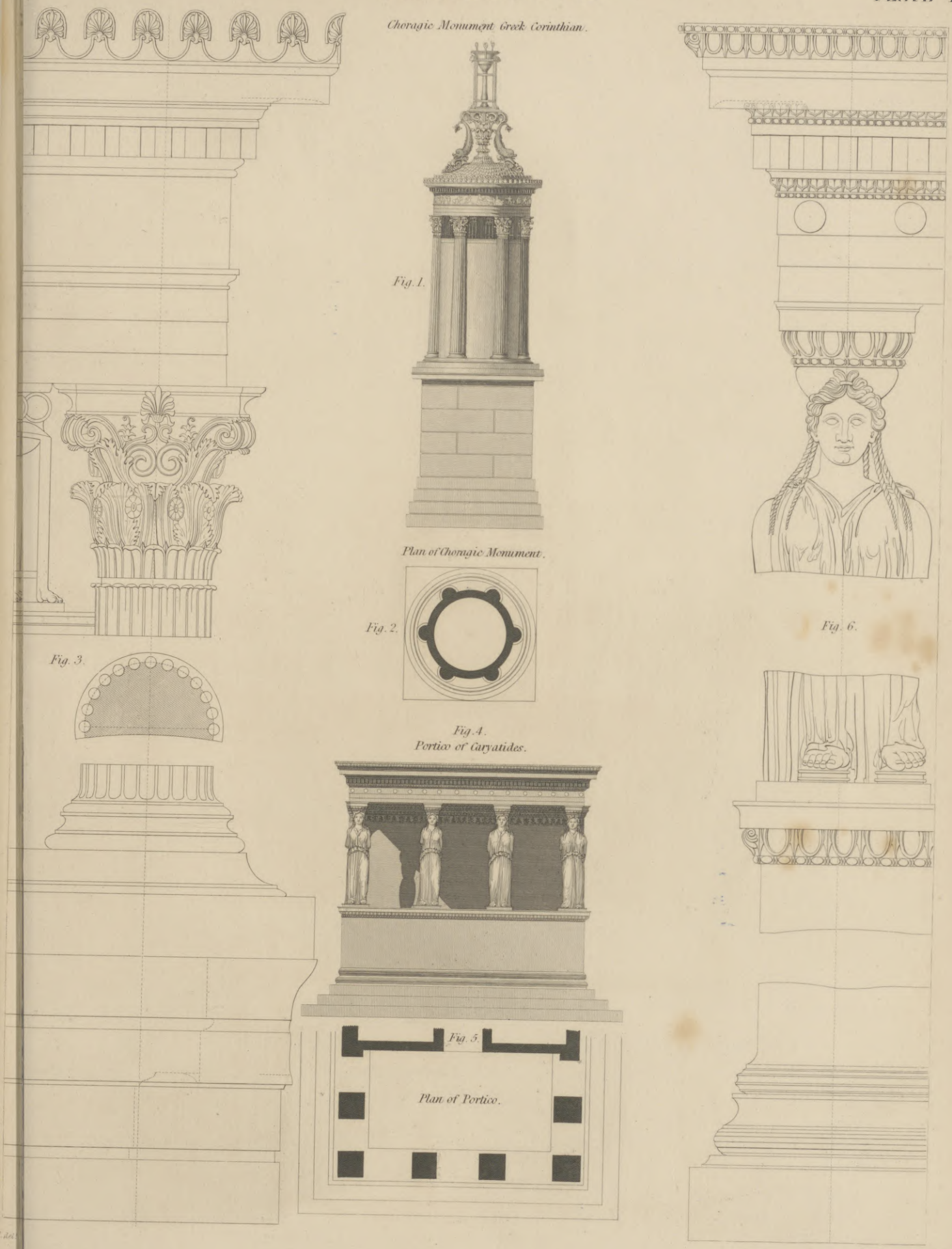


Fig. 3.



Engd. by G. Aikman, Edinr.

ARCHITECTURE.

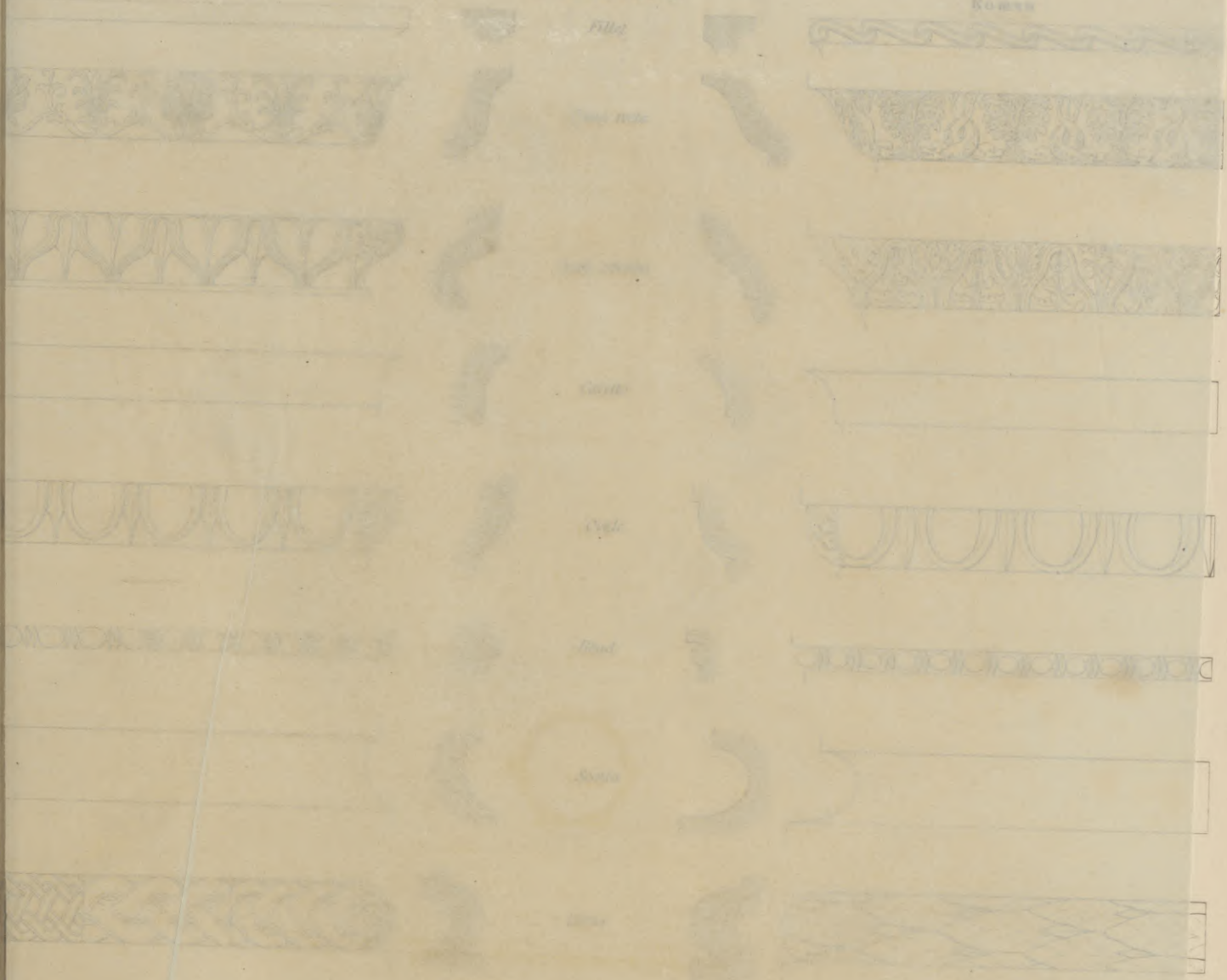
PLATE LXI

Grooves

MOULDINGS.

Fillet

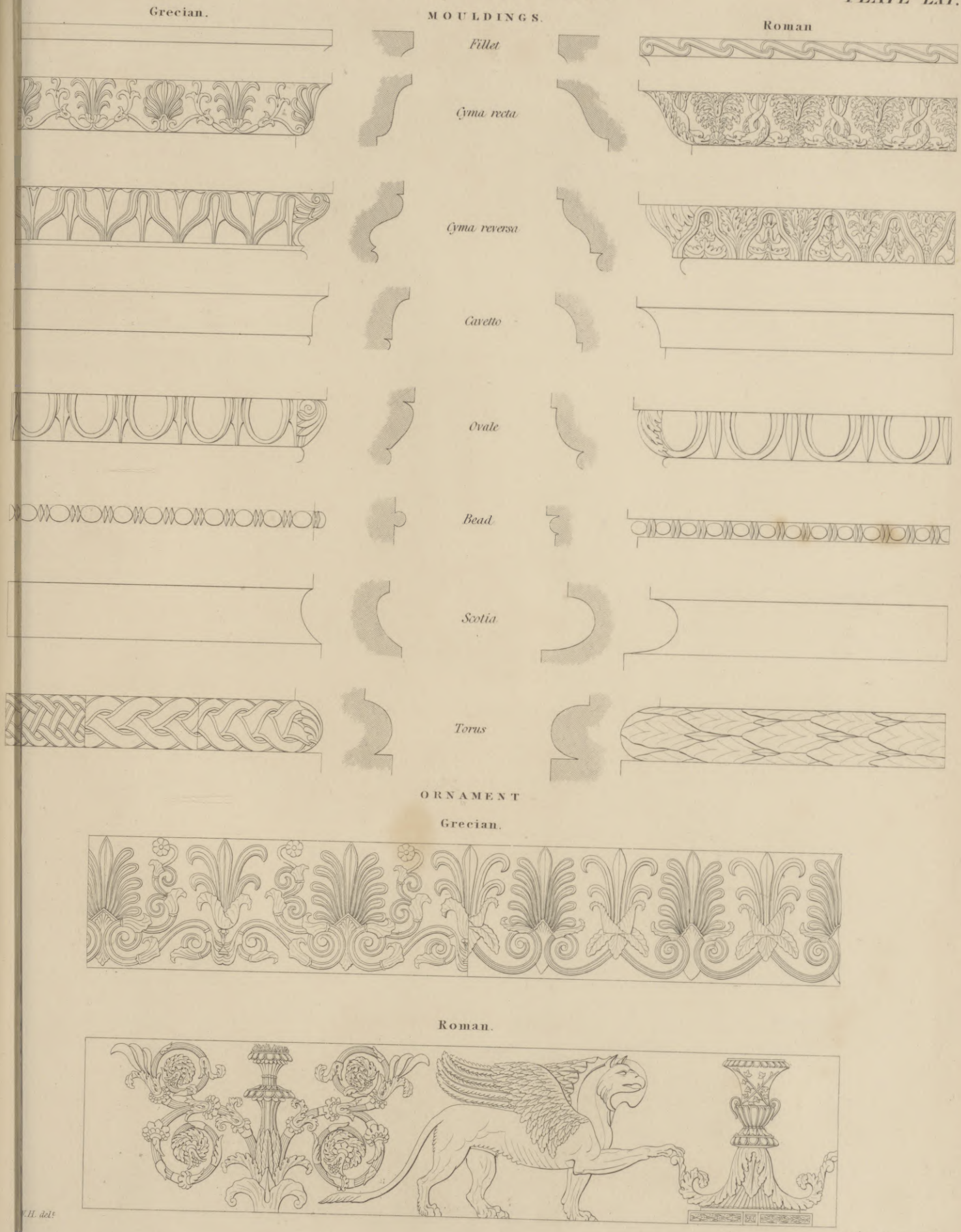
Roman



Edin.r

ARCHITECTURE.

PLATE LXI.



W.H. del.t

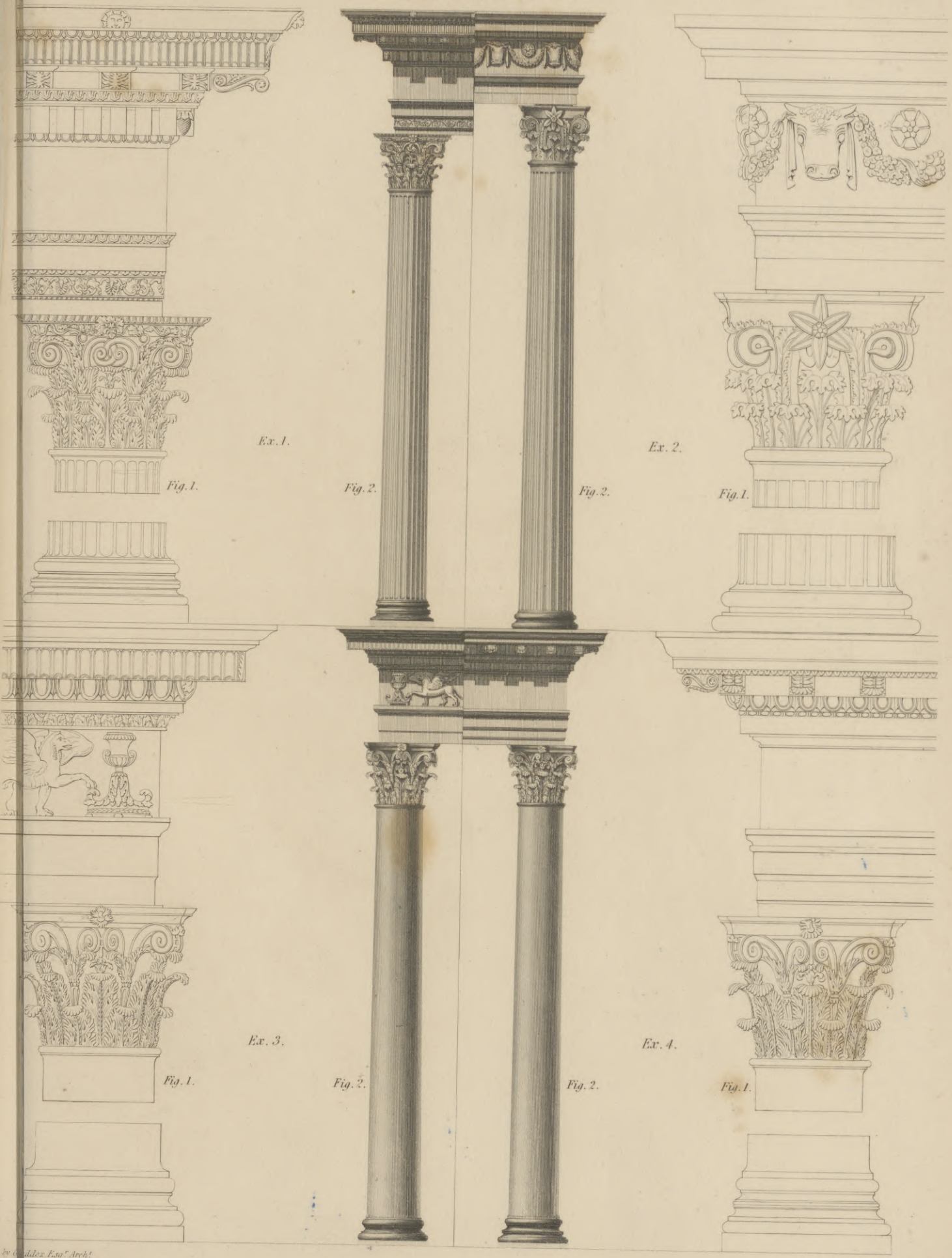
Eng.d by G. Aikman. Edin.r

Examples of the Roman Corinthian.

ARCHITECTURE.

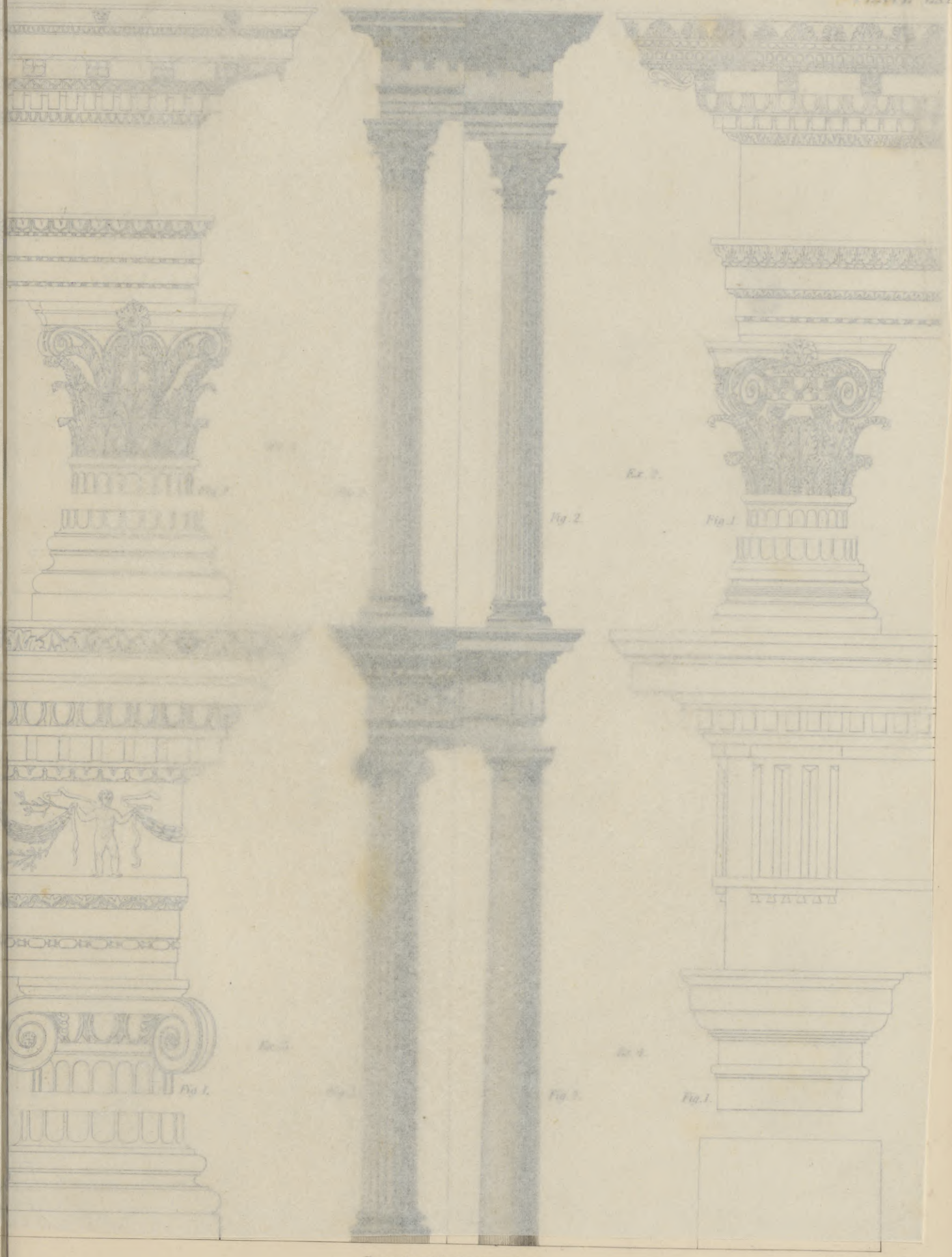
PLATE LXII.

Examples of the Roman Corinthian.



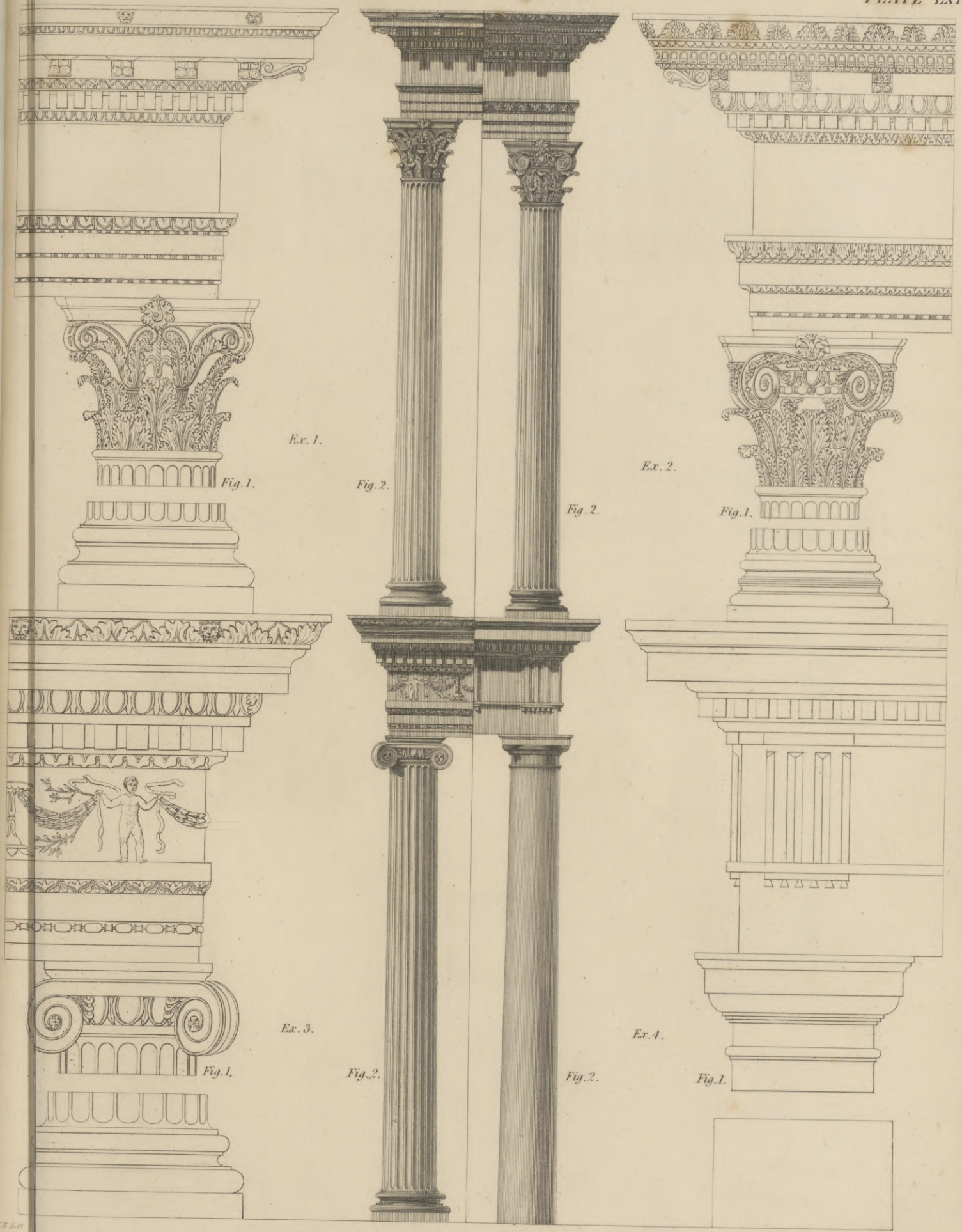
by G. Addex Esq.r Arch.t

Eng.d by G. Aikman, Edin.r



Examples of the Roman Orders

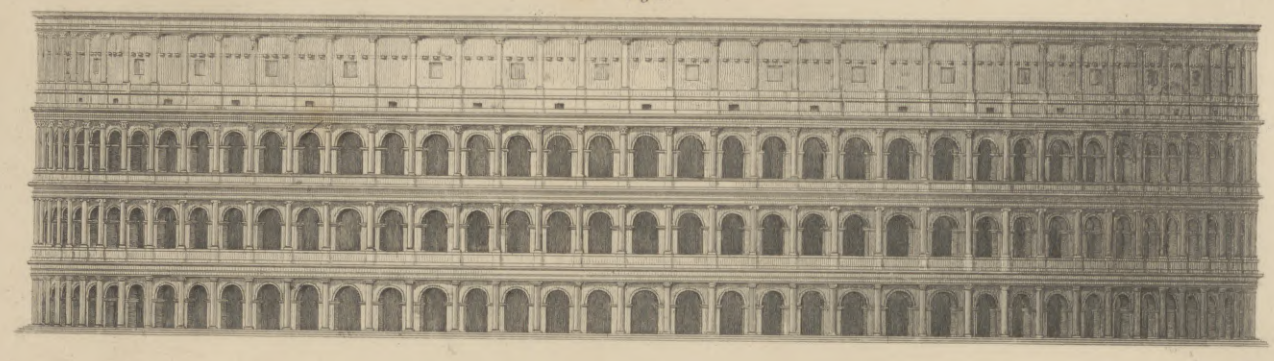
Engd by G. Aikman, Edinr.



Examples of the Roman Orders

Engd. by G. Aikman, Edinr.

Fig. 1.



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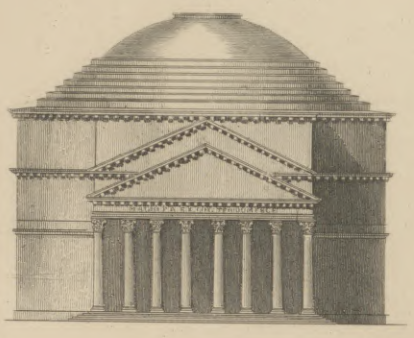

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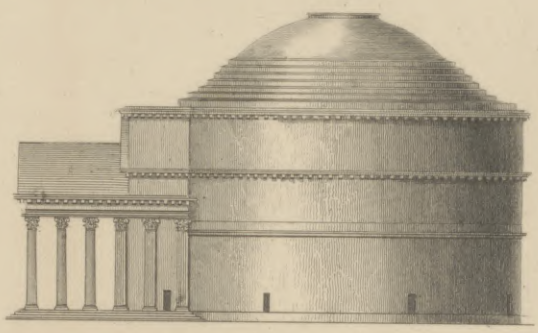

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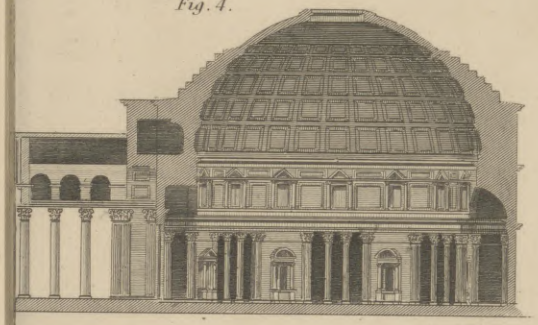


Fig. 5.

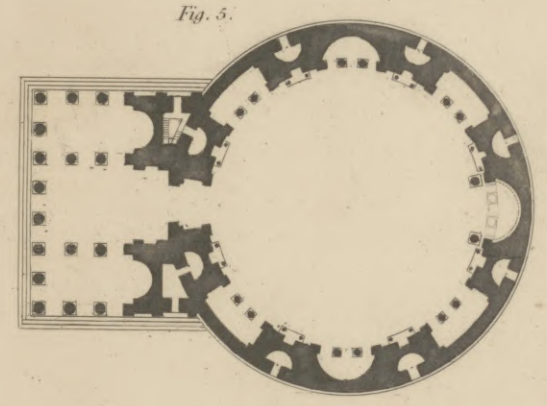
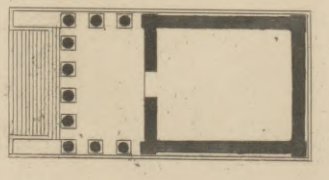


Fig. 6.

Fig. 7.



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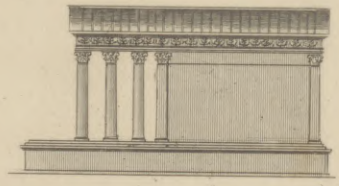
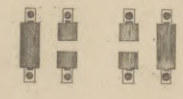


Fig. 9.

Fig. 10.



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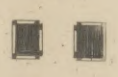

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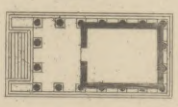
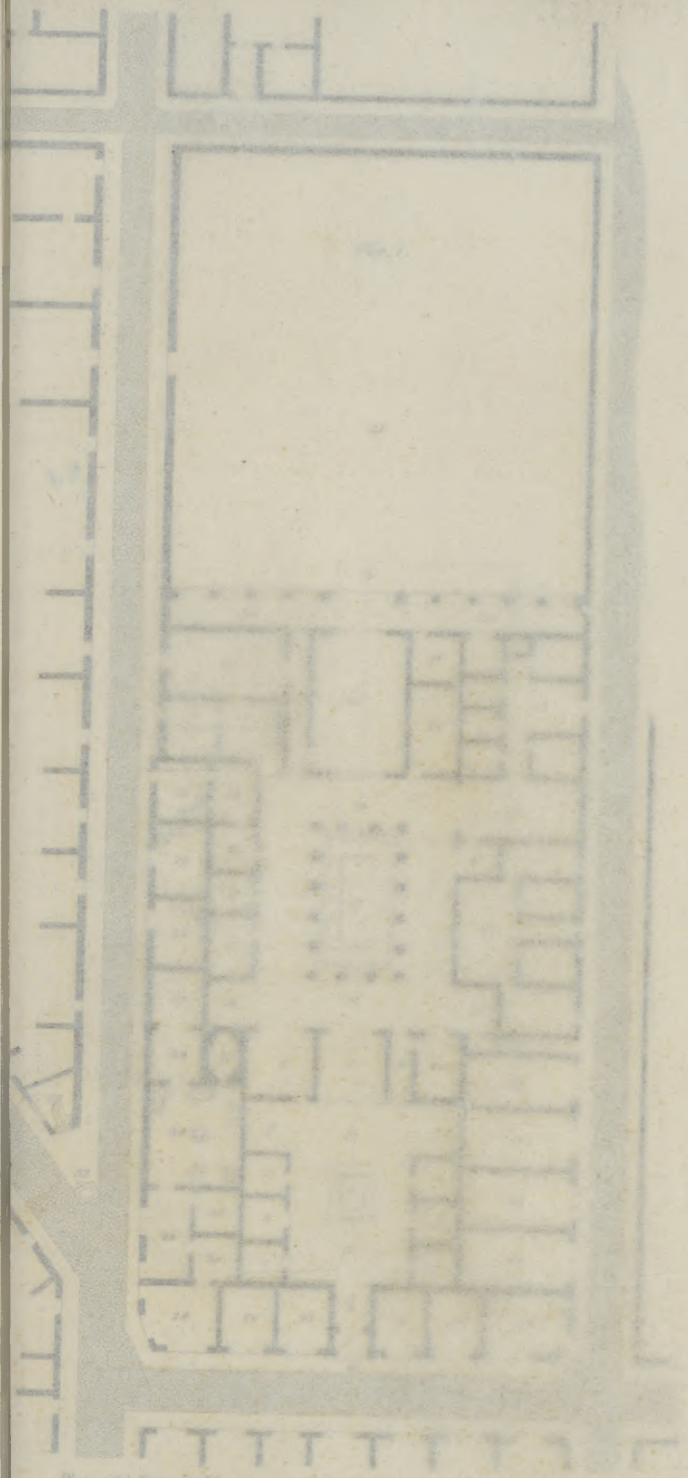


W. del.t

Eng.d by G. Aikman. Edin.r

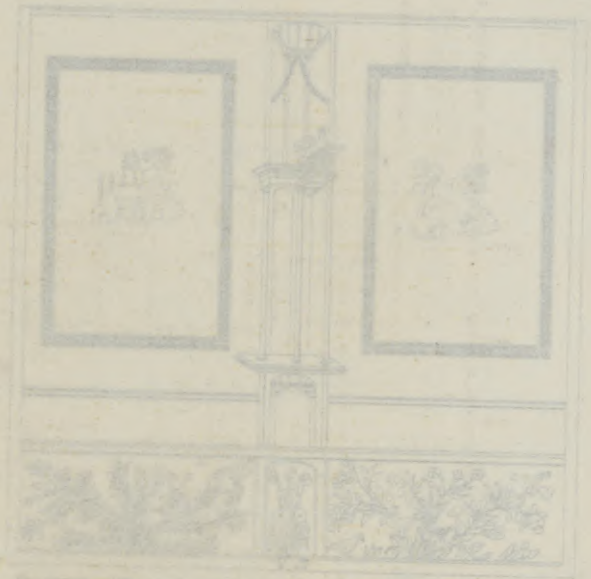


Plan of a Roman Mansion, with the [illegible]
from Pompeii.

Fig. 4.

Sketch of the Entrance to the Mansion (Figs. 1, 2 & 3) in its present state.

Fig. 5.



[illegible] the sides of rooms in Pompeii.

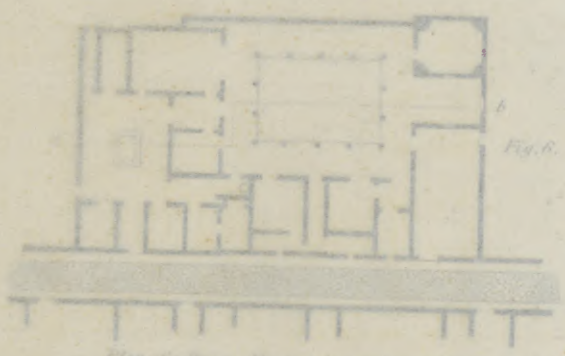


Fig. 6.

Plan of a Roman Mansion in a private street.
from Pompeii.

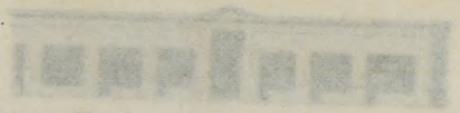
Fig. 2.

Section of the above Mansion (Fig. 2) on the [illegible]

Fig. 7.

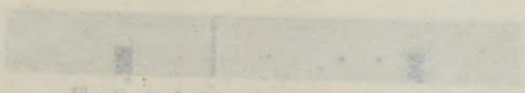
Section of the above Mansion (Fig. 6) on the line b b.

Fig. 3.



Entrance Elevation to the street of the above Mansion (Fig. 1).

Fig. 8.



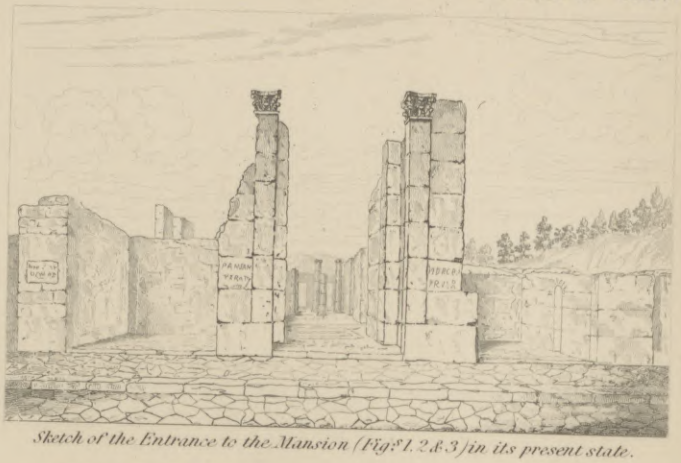
Elevation to the street of the above Mansion (Fig. 6).

Engd. by T. Allman, 1816.

Fig. 1.

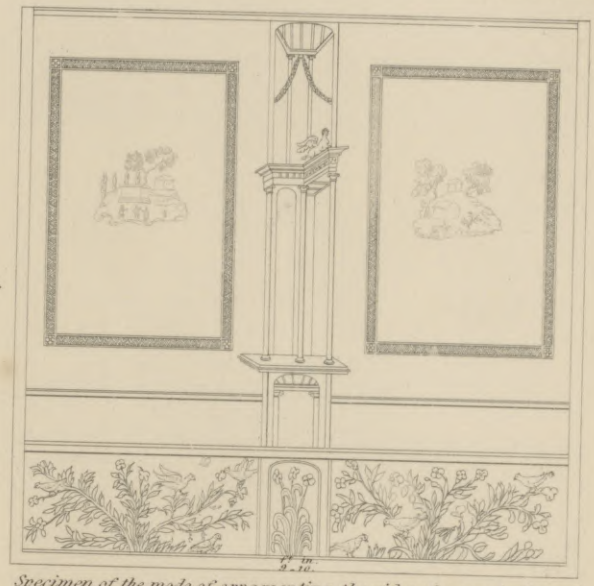
Plan of a Roman Mansion, with the houses, shops & streets, surrounding it, from Pompeii.

Fig. 4.



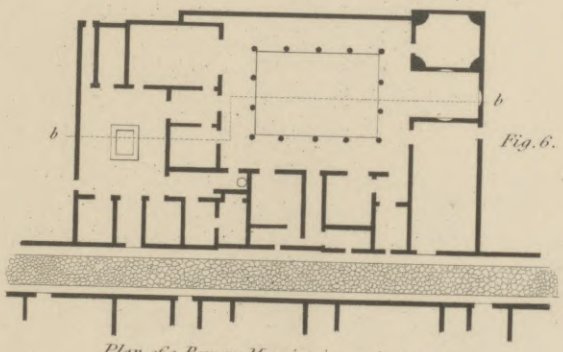
Sketch of the Entrance to the Mansion (Figs. 1, 2 & 3) in its present state.

Fig. 5.



Specimen of the mode of ornamenting the sides of rooms in Pompeii.

Fig. 6.

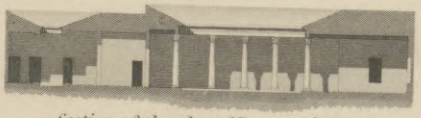


Plan of a Roman Mansion in a private street, from Pompeii.

Fig. 2.

Section of the above Mansion (Fig. 1) on the line a.a.

Fig. 7.

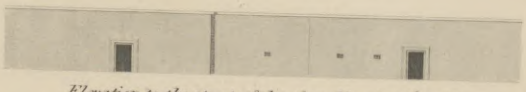


Section of the above Mansion (Fig. 6.) on the line b.b.

Fig. 3.

Entrance Elevation to the street of the above Mansion (Fig. 1)

Fig. 8.

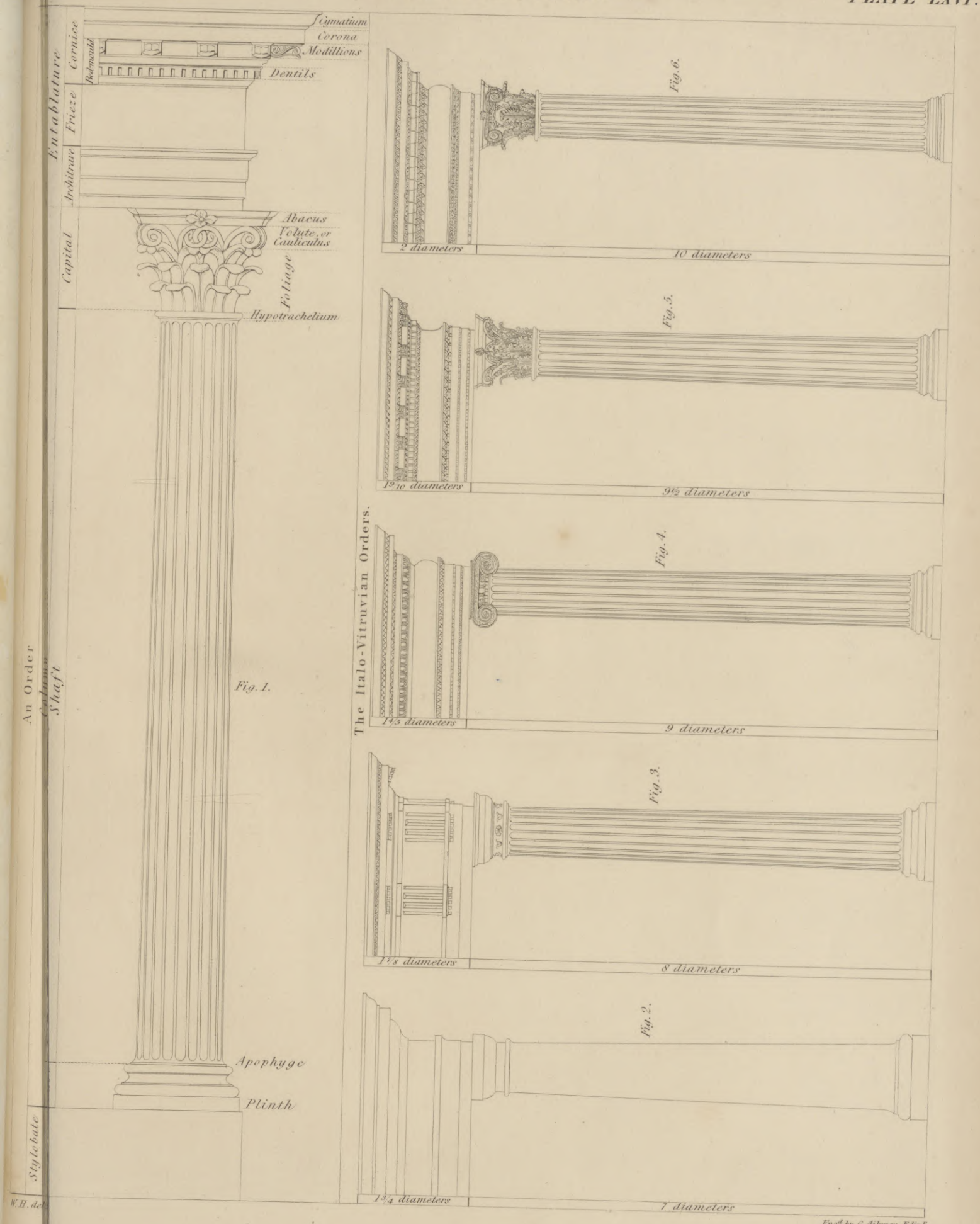


Elevation to the street of the above Mansion (Fig. 6.)

Scale of 10 5 0 10 20 30 40 50 60 70 80 90 100 feet

W.H. del.

Engd. by G. Aikman, Edinr.


An Order
Stylobate
Column
Shaft
Entablature
Cornice
Frieze
Architrave
Capital
Cymatium
Corona
Modillions
Bedmould
Dentils
Abacus
Volute, or Cauliculus
Foliage
Hypotrachelium
Fig. 1.
Apophyge
Plinth
The Italo-Vitruvian Orders.
Fig. 6.
2 diameters
10 diameters
Fig. 5.
1 9/10 diameters
9 1/2 diameters
Fig. 4.
1 4/5 diameters
9 diameters
Fig. 3.
1 7/8 diameters
8 diameters
Fig. 2.
1 3/4 diameters
7 diameters
W. H. del.
Engd. by G. Aikman, Edinr.

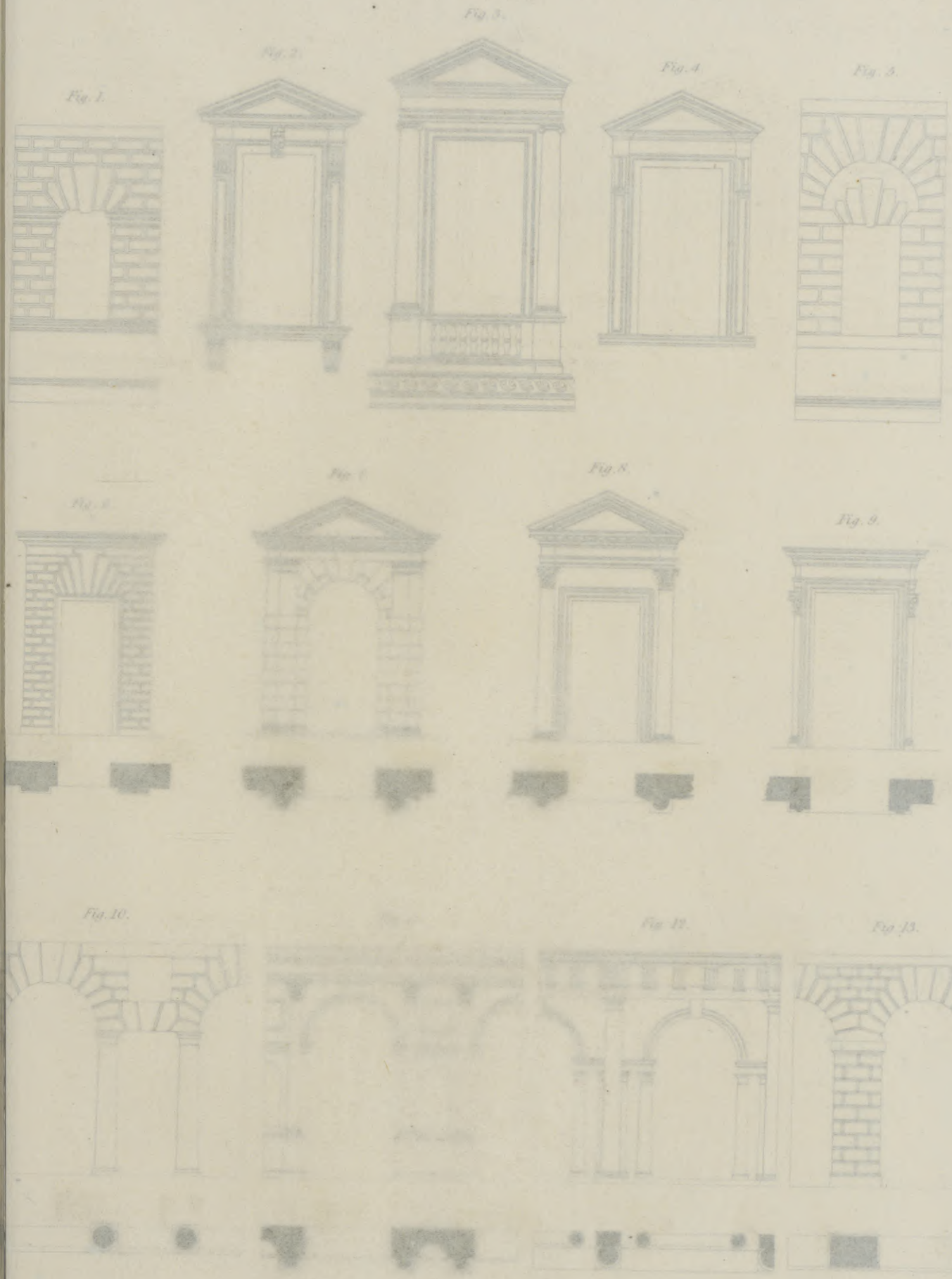
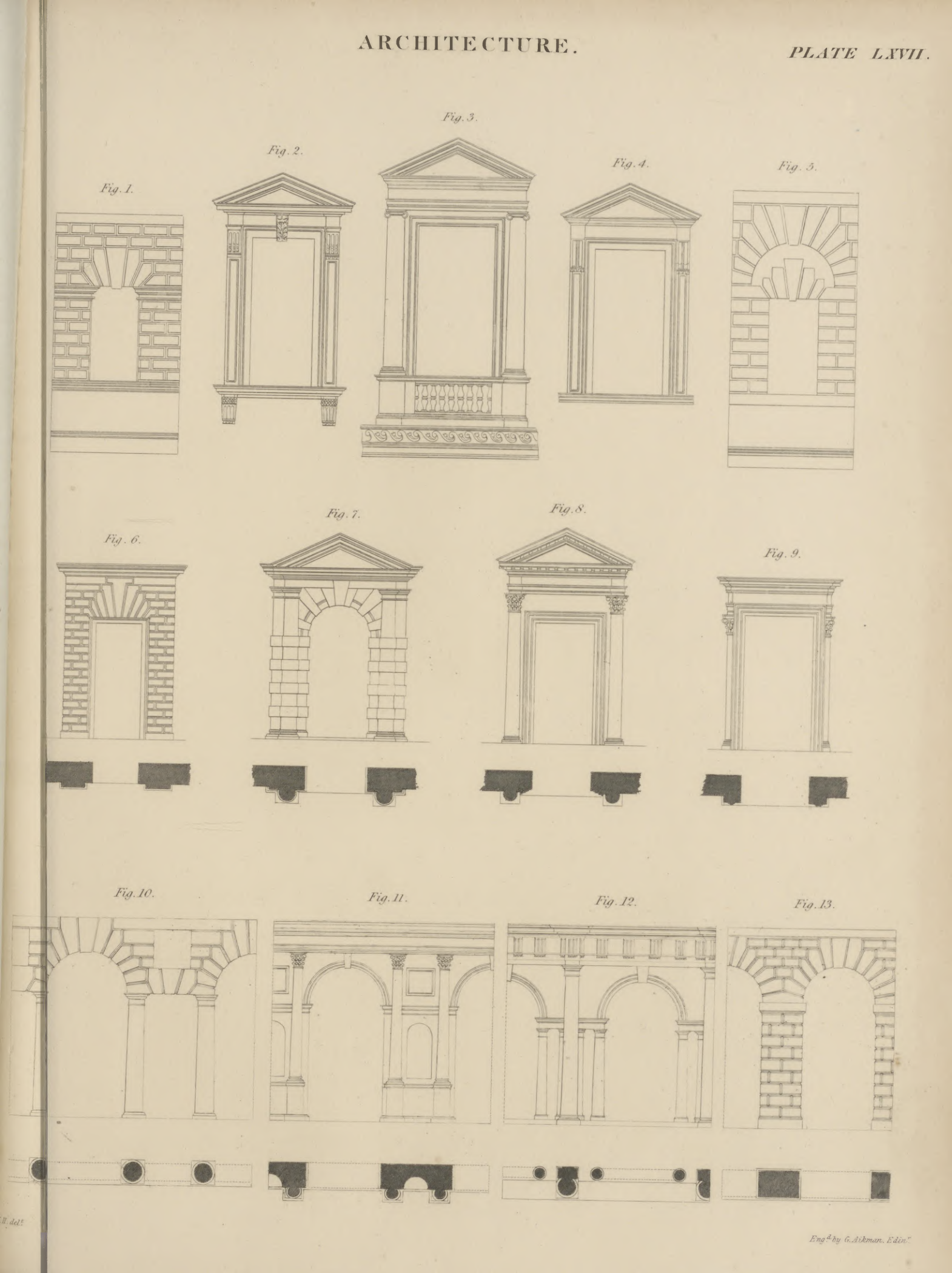


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.



Engd. by G. Aikman. Edinr.

ST PAUL'S

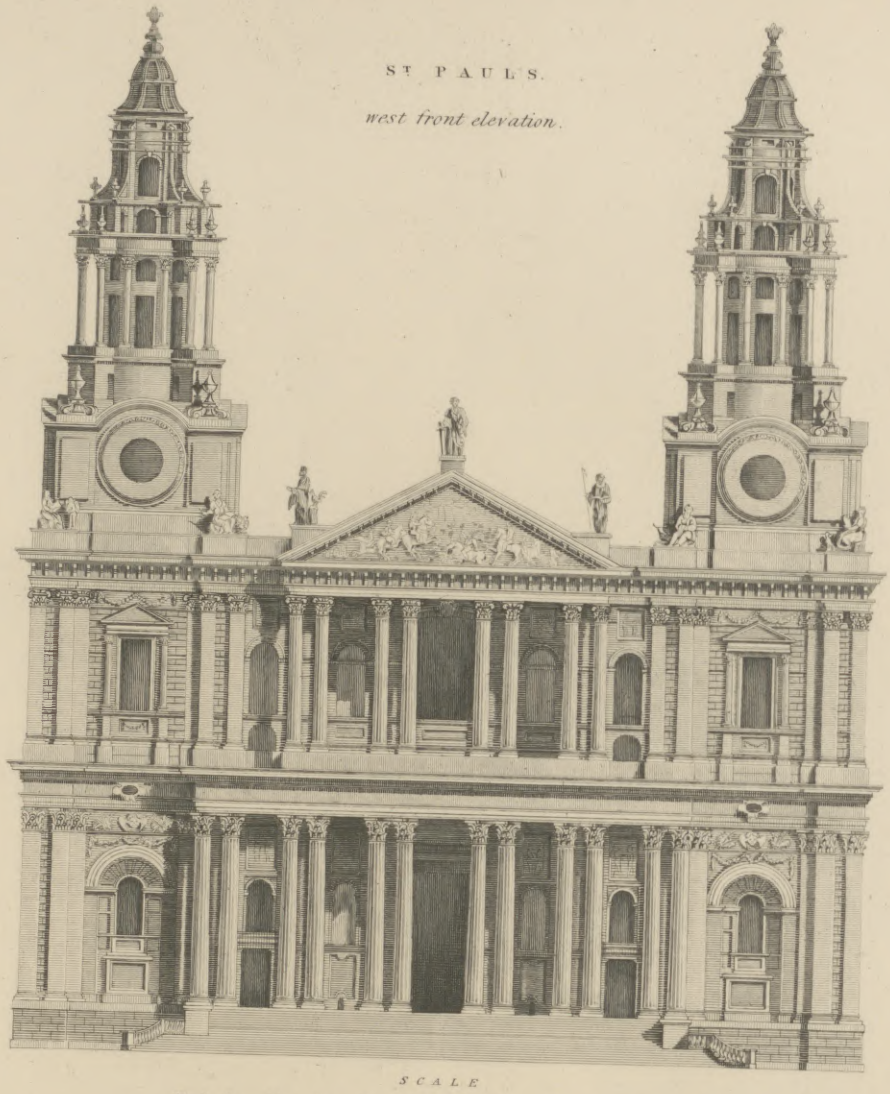
west front elevation

east front elevation

Engd by G. Aikman, Edinr

ST PAUL'S.

west front elevation.



SCALE

10 5 0 10 20 30 40 50 60 70 80 90 100 Feet.

ST PETERS.

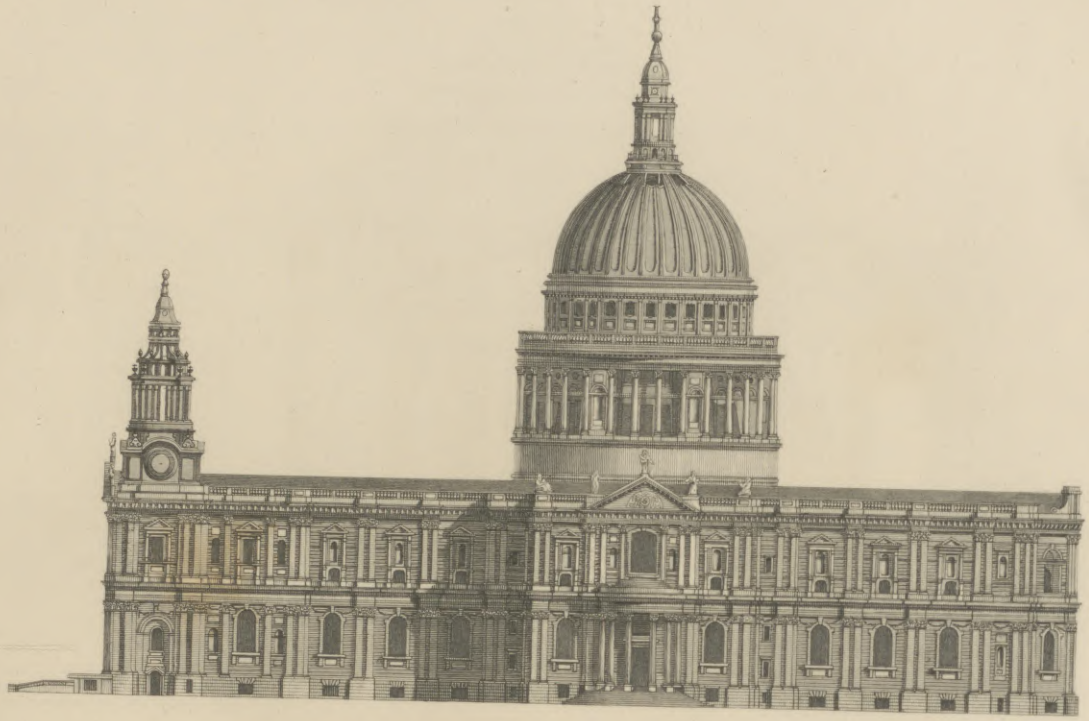
east front elevation.

Drawn by J. Foore, Esq.r Archt

Engd by G. Aikman, Edin.r

ST PAUL'S

ST PETER'S



ST PAUL'S.

(South Flank Elevation.)

ST PETER'S.

(North Flank Elevation.)

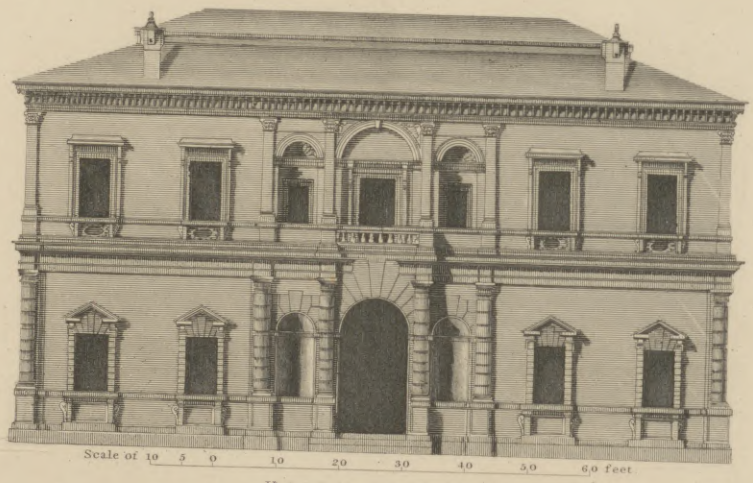
SCALE

0 50 100 200 300 Feet

Fig. 3.

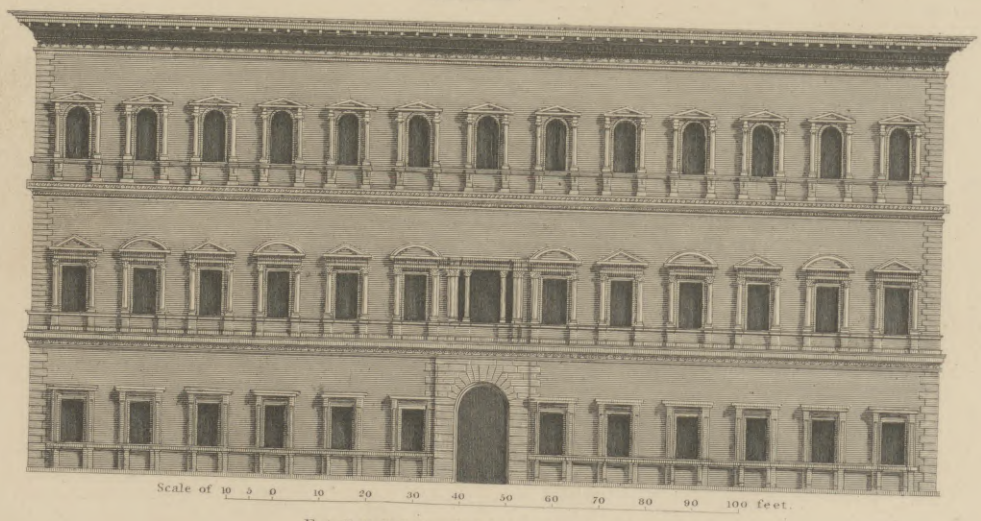
VILLA CAPRA
near Vicenza.

Fig. 2.



VILLA GIULIA
near Rome.

Fig. 1.



FARNESE PALACE — ROME
front elevation.

Drawn by P. Ware, Esq.r Arch.t

Engd by G. Aikman, F.S.A.

...om the Nave of St. Alban's Abbey Church.

Arches from a Chapel in the White Tower, London.

Arches from the Conventual Church, Ely.

Arches from Waltham Abbey Church, Herts.

Window from [illegible]

Window from [illegible] Church, Sussex.

Doorway from Iffley Church, Oxfordshire.

Doorway from Iffley Church, Oxfordshire.

Window from Pythagoras's School, Cambridge.

Window from [illegible]

[illegible] Church, Hampshire.

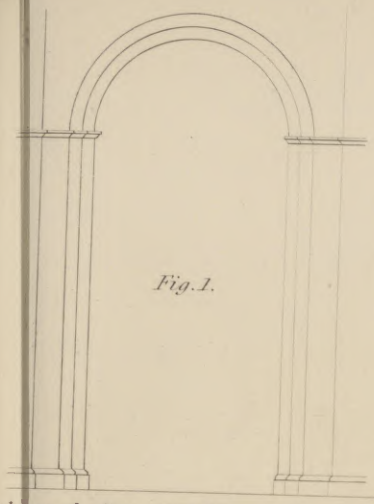
Window from Chichester Cathedral.

Arches from [illegible] Church, Sussex.

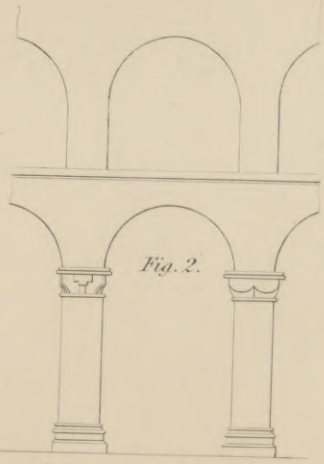
Arches from the Nave of Salisbury Cathedral.

W. del.t

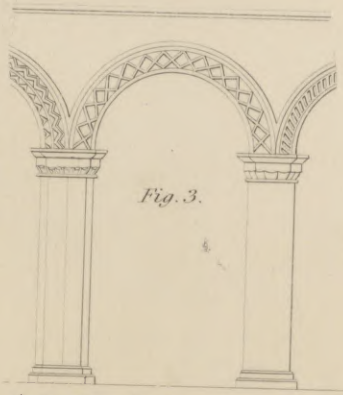
Engd. by G. Aikman, Edin.r



Arch from the Nave of St. Alban's Abbey Church.



Arches from a Chapel in the White Tower, London.

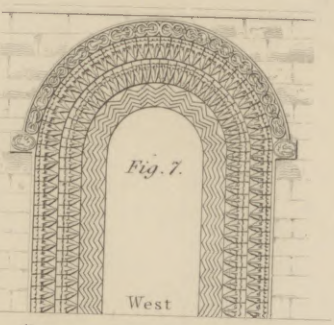


Arches from the Conventual Church. Ely.

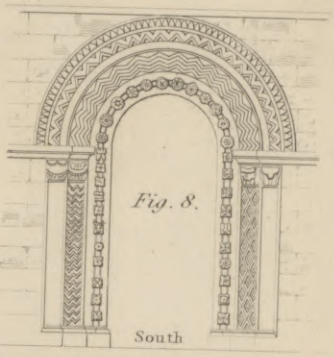
Arches from Waltham Abbey Church, Herts.

Window from Steyning Church, Sussex.

Window from Steyning Church, Sussex.

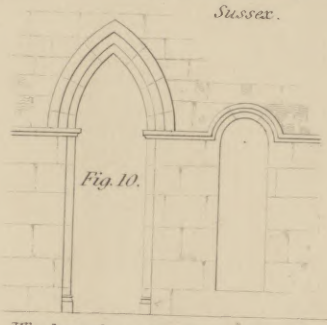


Doorway from Iffley Church, Oxfordshire.



Doorway from Iffley Church, Oxfordshire.

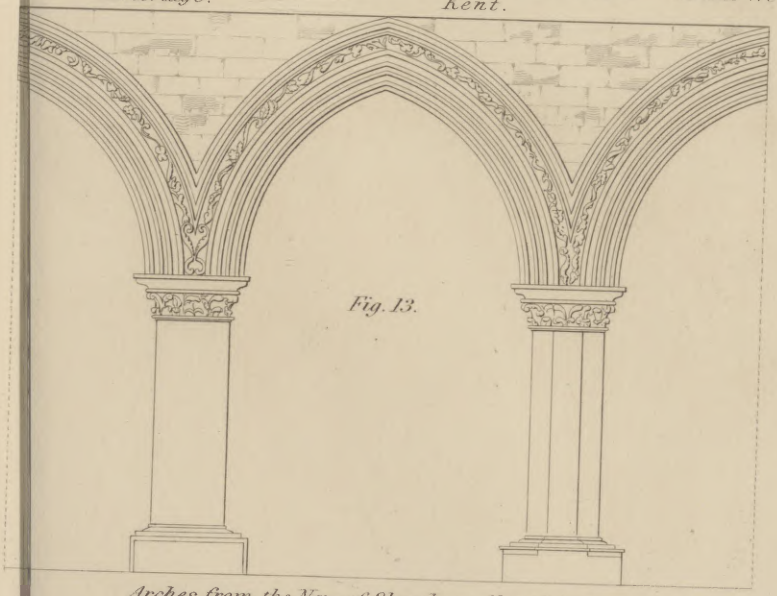
Window from Pythagoras's School, Cambridge.



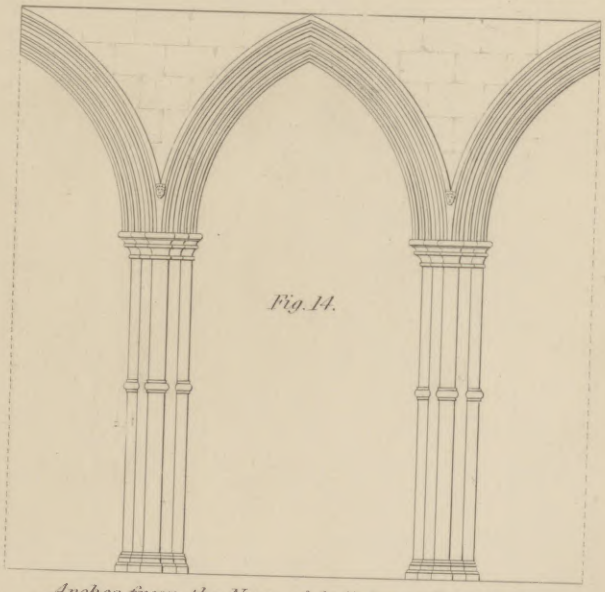
Windows from Barfreston Church, Kent.

Arches from Romsey Church, Hampshire.

Window from Chichester Cathedral.



Arches from the Nave of Shoreham Church, Sussex.



Arches from the Nave of Salisbury Cathedral.

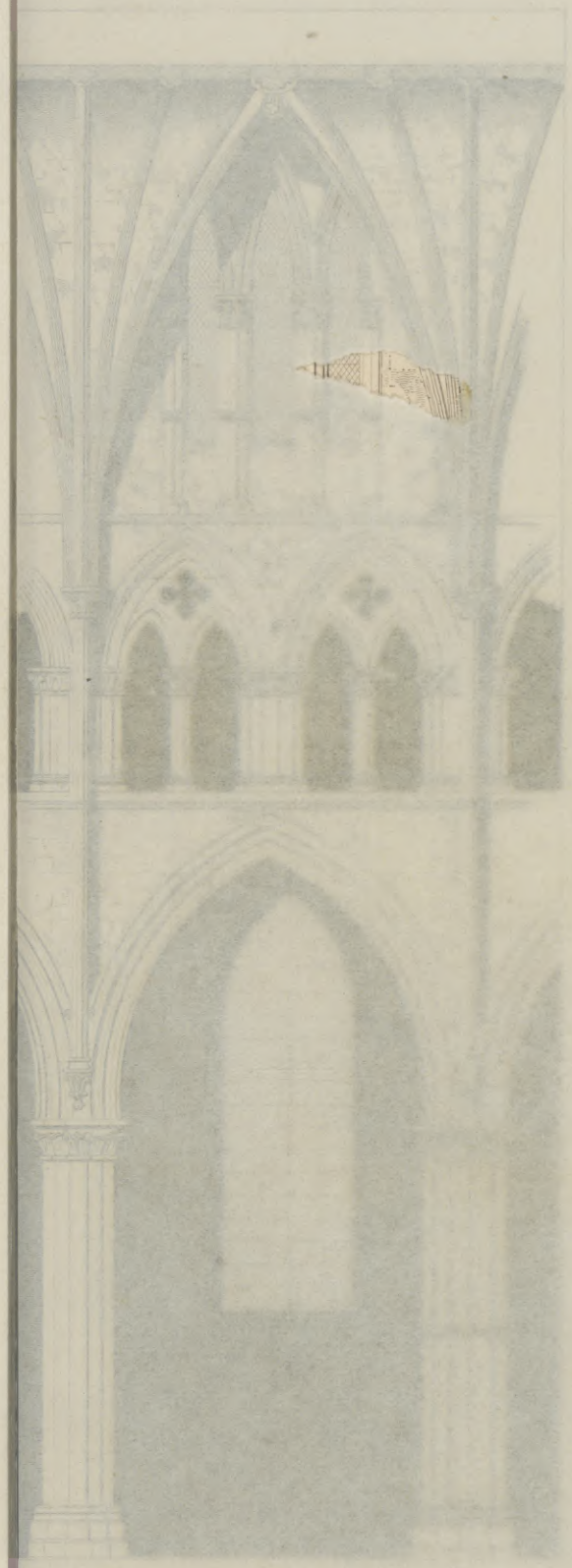
W. del.t

Engd by G. Aikman, Edin.r

W. H. del.

Engd. by G. Aikman. Edinr.

Sectional compartment of the Nave of Lincoln Cathedral.



Sectional compartment of the Choir of Lincoln Cathedral.

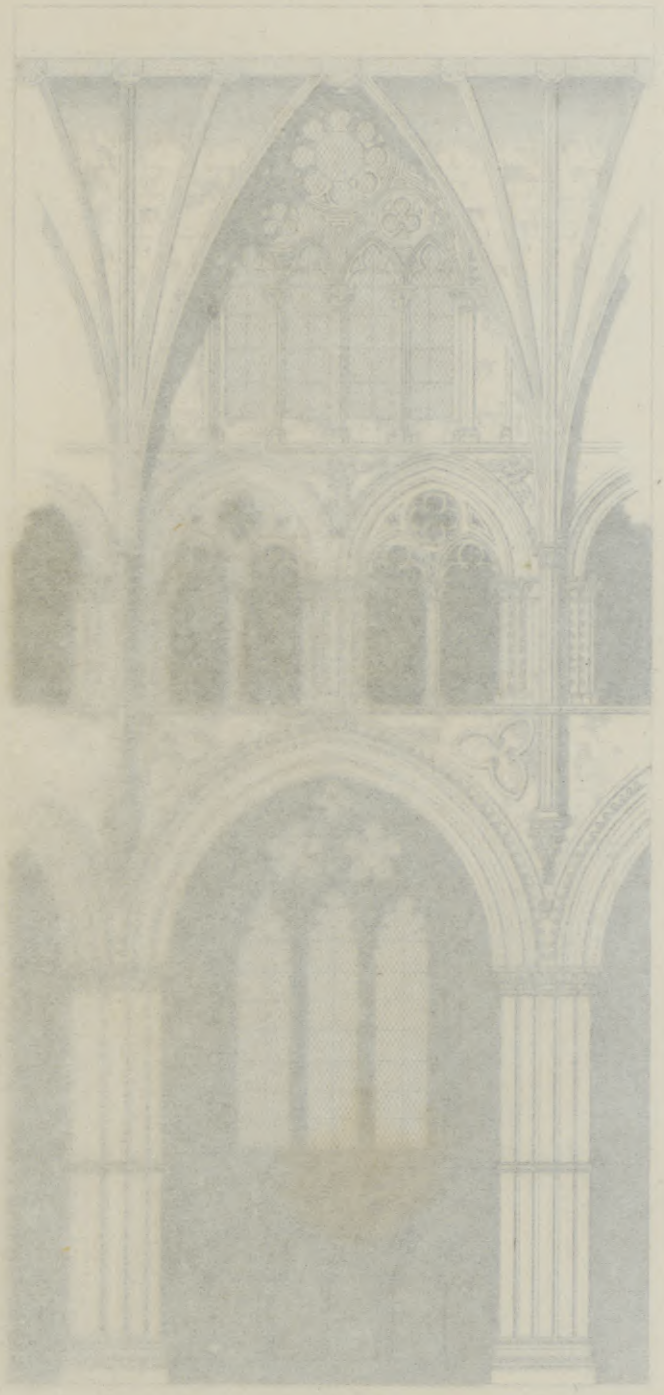
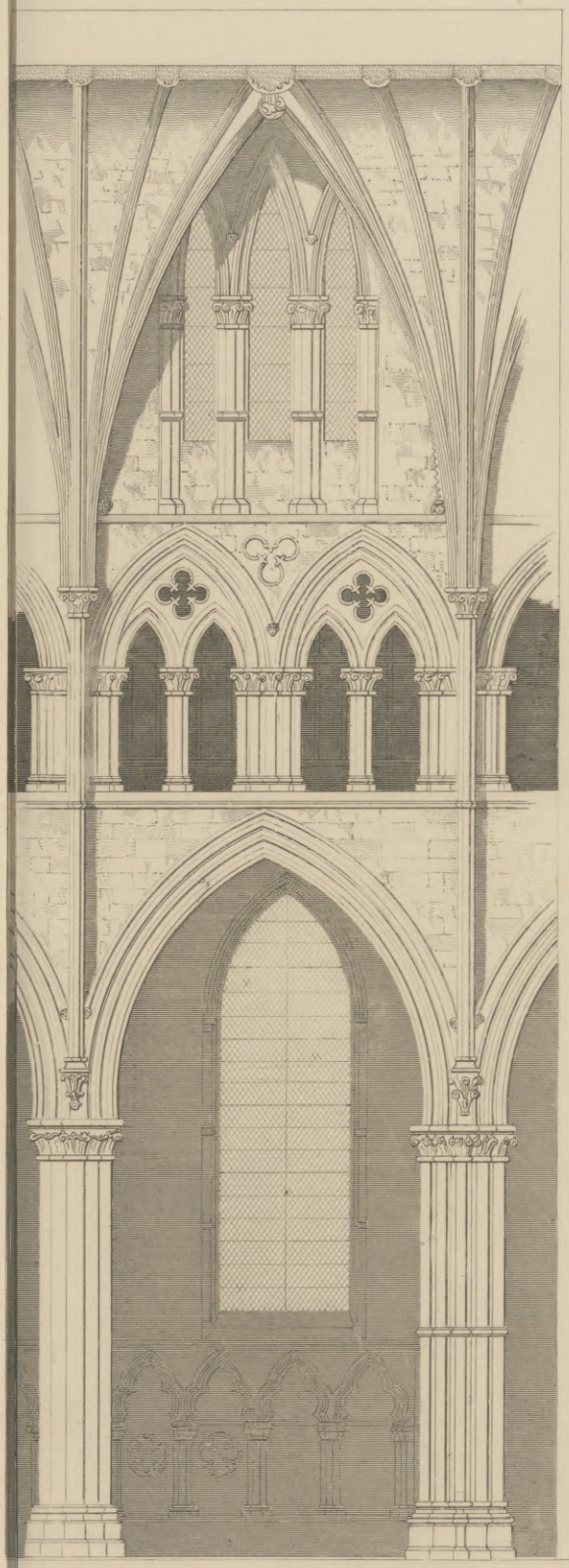


Fig. 2.

Engd by G. Ashman

Sectional compartment of the Nave of Lincoln Cathedral.



Sectional compartment of the Choir of Lincoln Cathedral.

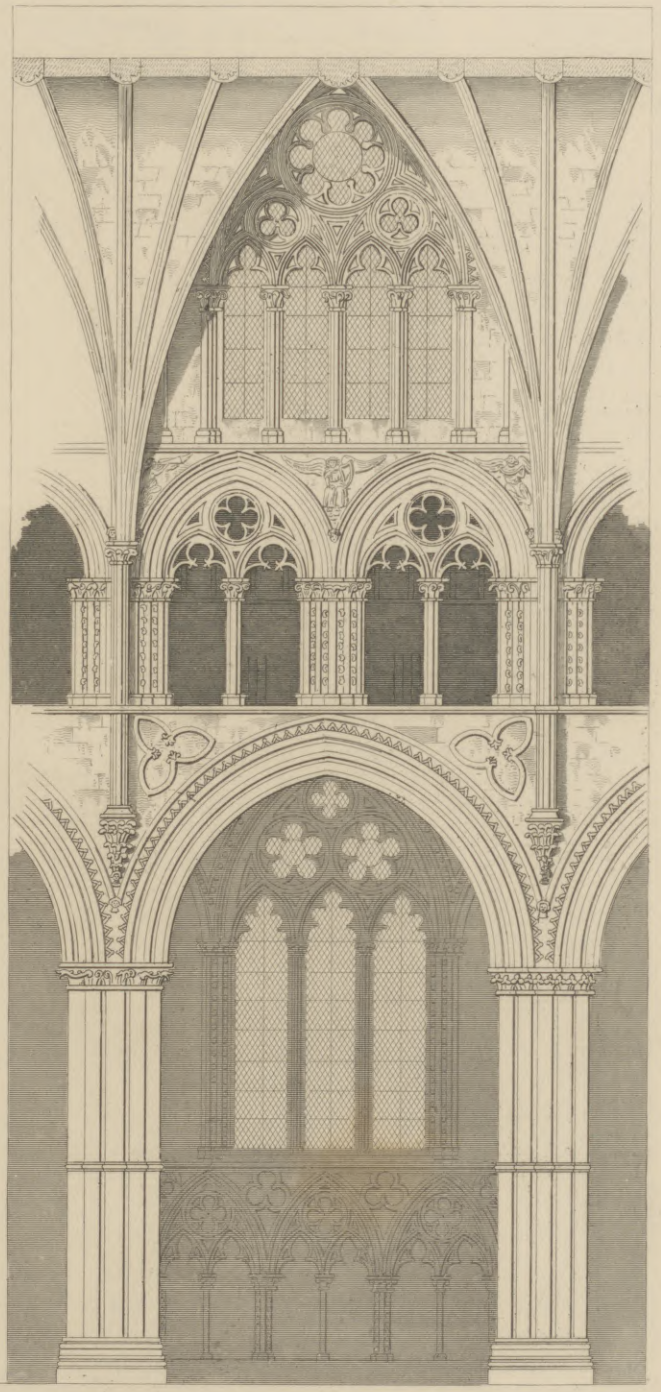


Fig. 1.

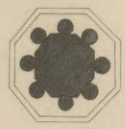
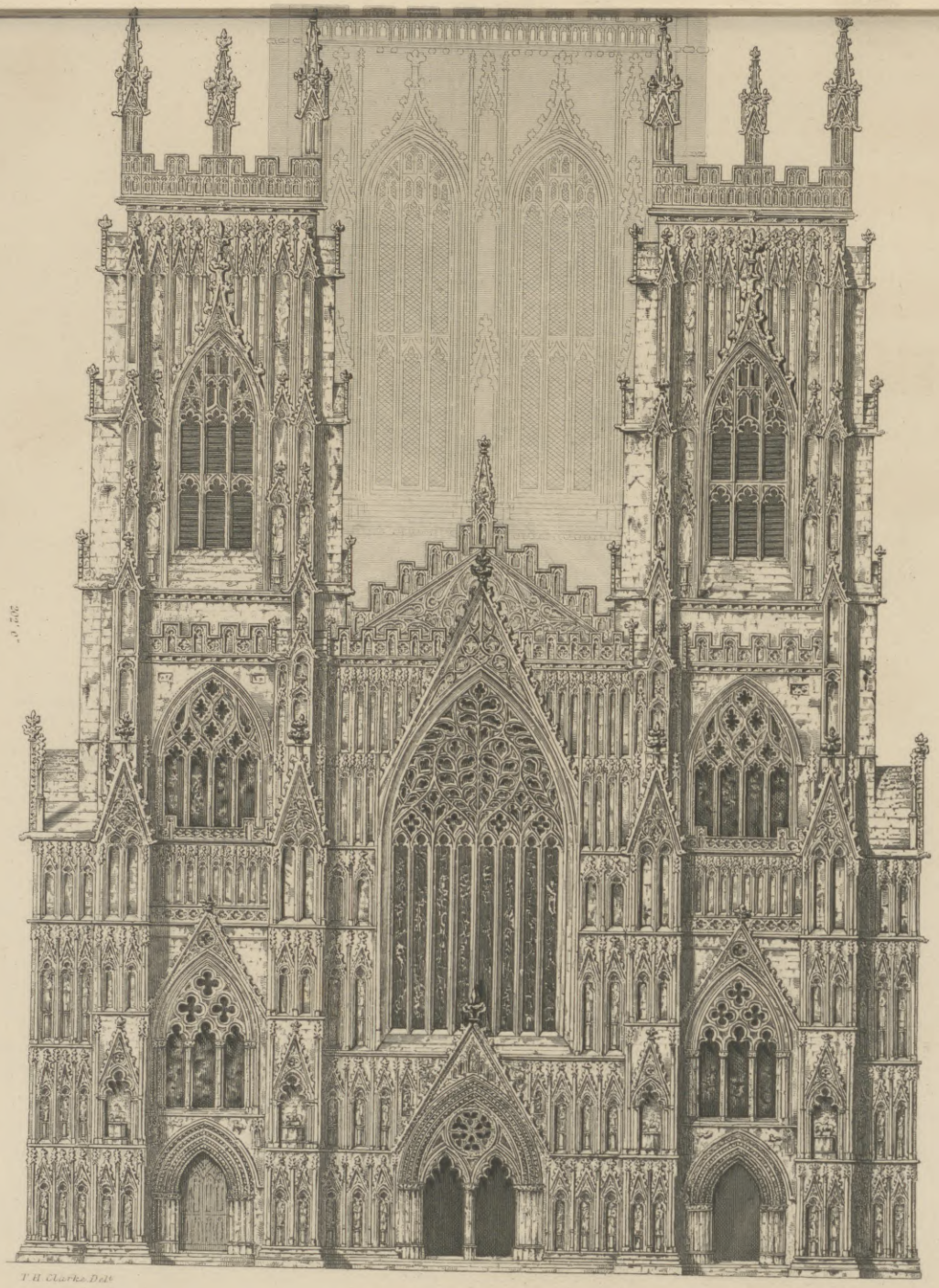


Fig. 2.

Engd. by G. Aikman, Edinr.



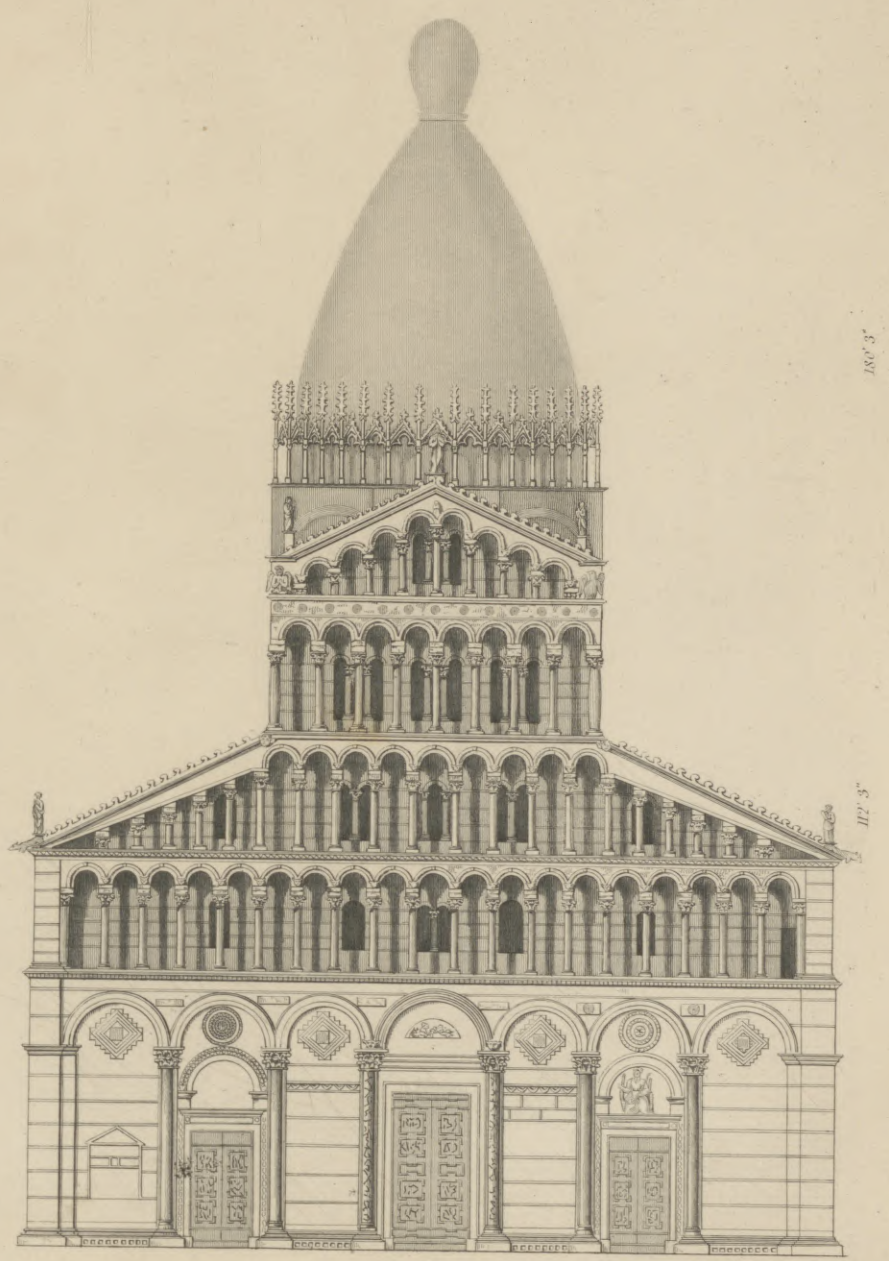
T. H. Clarke Delt.

YORK CATHEDRAL.

(West Front)

SCALE.

10 5 0 10 20 30 Feet

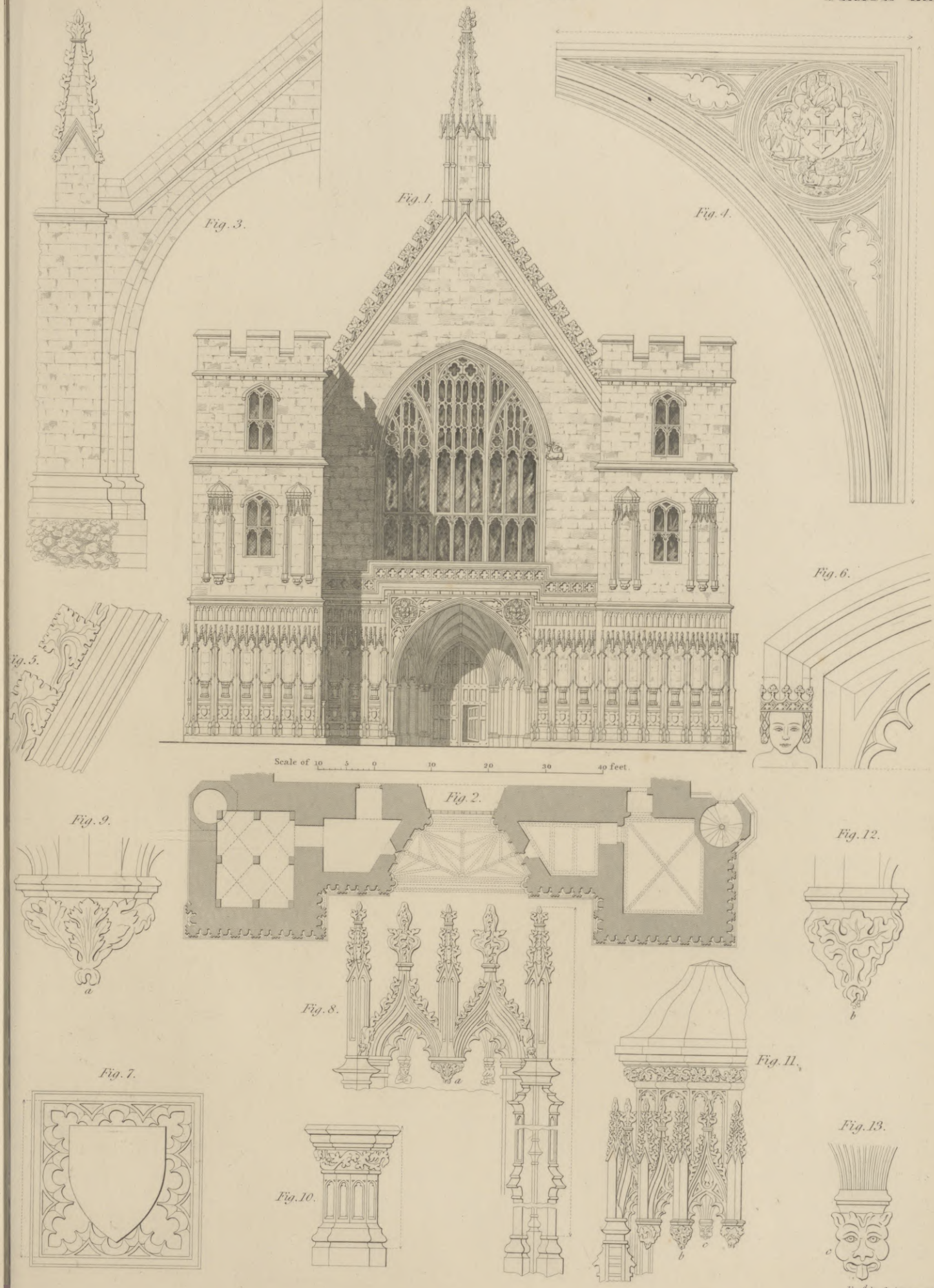


PISA CATHEDRAL.

(West Front)

Engd by G. Aikman Edin.r

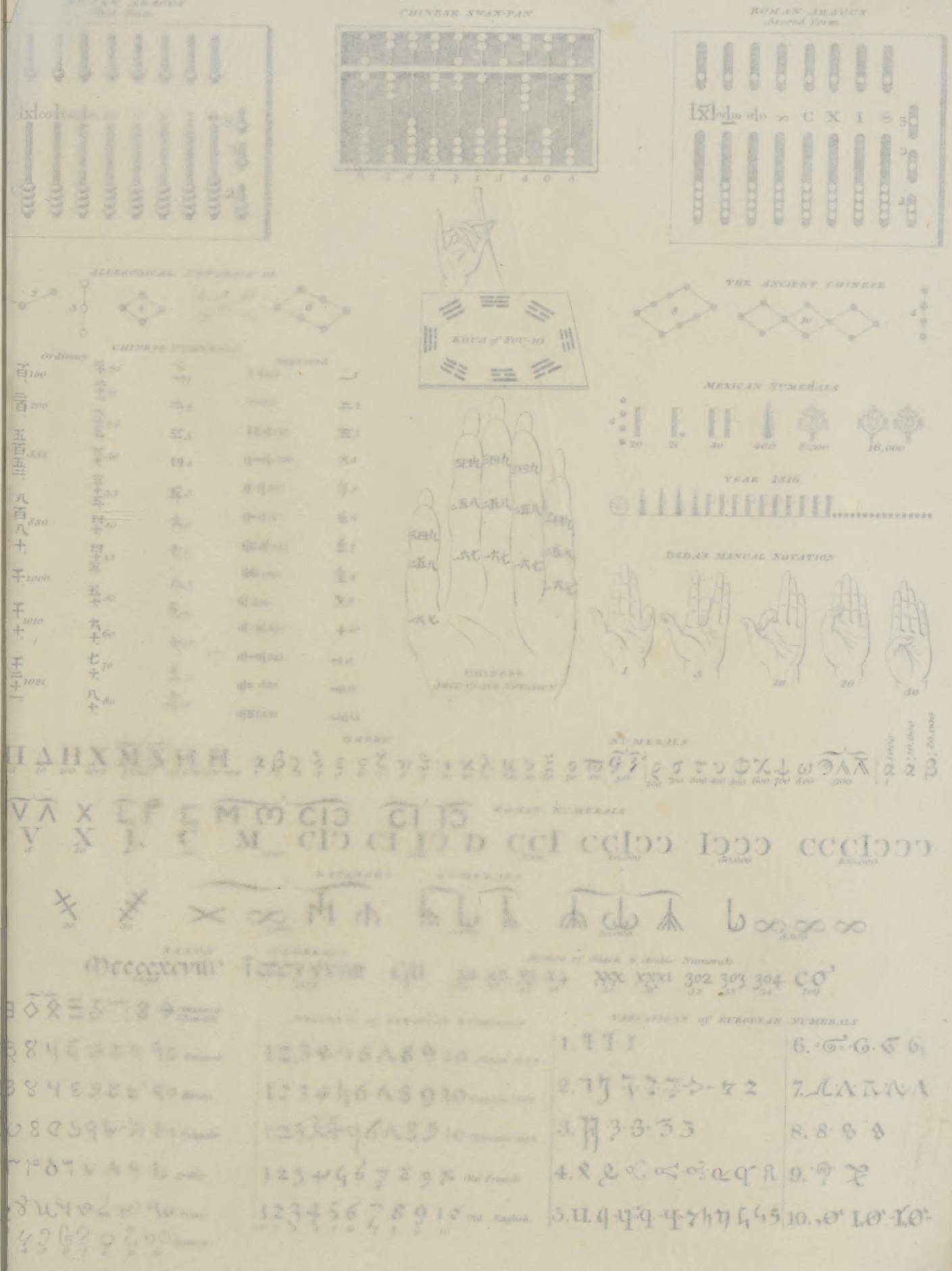
Eng.d by G. Aikman, Edin.r



Eng.d by G. Aikman, Edin.r

ARITHMETIC.

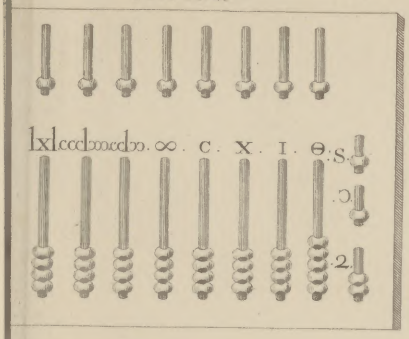
PLATE LXXVI.



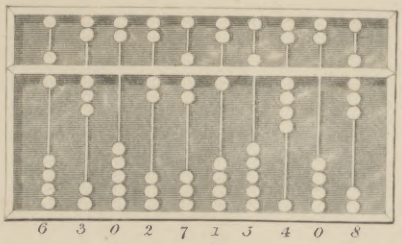
ARITHMETIC.

PLATE LXXVI.

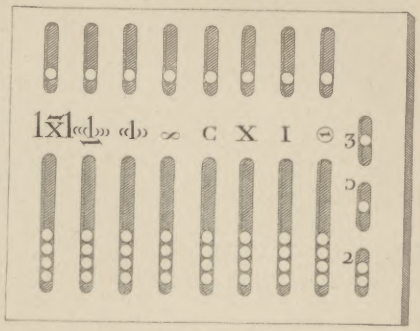
ROMAN ABACUS
First Form



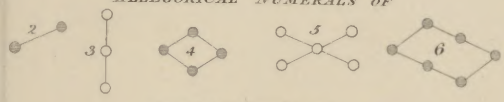
CHINESE SWAN-PAN



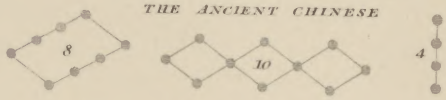
ROMAN ABACUS
Second Form



ALLEGORICAL NUMERALS OF

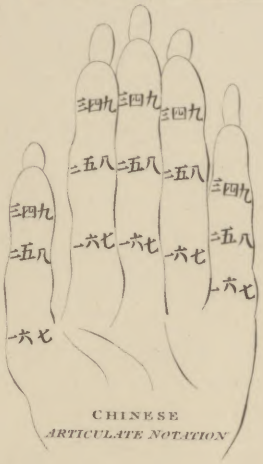


THE ANCIENT CHINESE



CHINESE NUMERALS

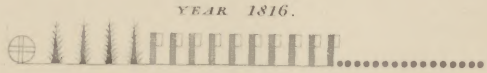
Ordinary			Improved	
百 100	二十 20	一 1	丨∘丨 101	一 1
二百 200	二十一 21	二 2	丨一 110	二 2
五百五二 552	二十五 25	三 3	丨三丨 132	三 3
八百八十 880	三十 30	四 4	丨or丨 ∘200	4
千 1000	三十五 35	五 5	丨∘丨 202	5
千十 1010	四十 40	六 6	丨一丨 212	6
千二十一 1021	四十五 45	七 7	丨三丨丨 233	7
	五十 50	八 8	丨≡ 260	8
	六十 60	九 9	丨丨 300	9
	七十 70	十 10	丨丨∘丨丨 303	10
	八十 80	十一 11	丨丨一丨丨 313	11
		十二 12	丨丨= 320	12
			丨丨三丨 331	13



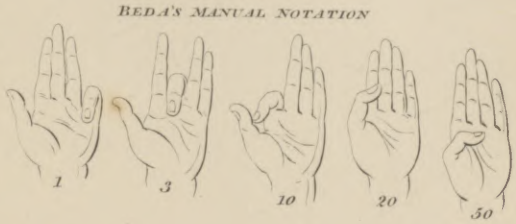
CHINESE
ARTICULATE NOTATION

MEXICAN NUMERALS

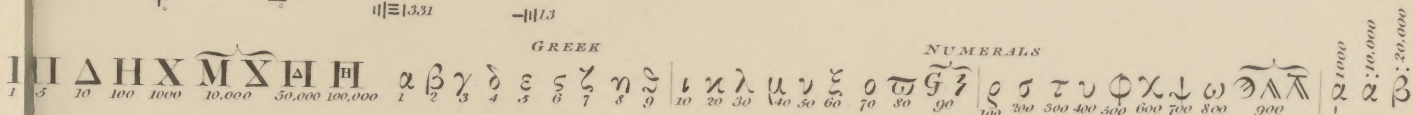
YEAR 1816.



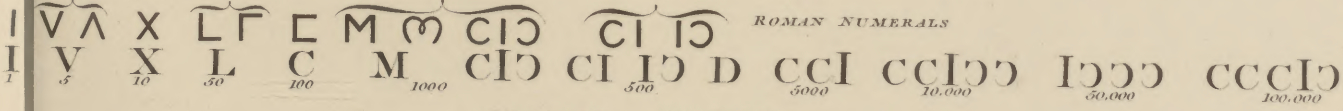
BEDA'S MANUAL NOTATION



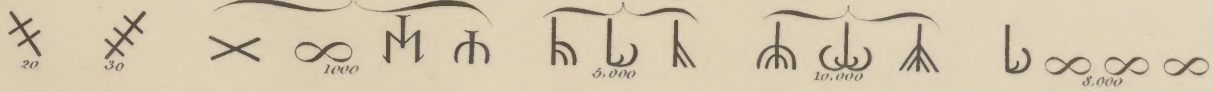
GREEK NUMERALS



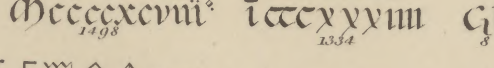
ROMAN NUMERALS



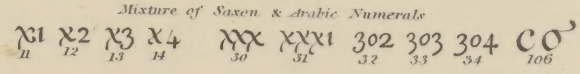
LAPIDARY NUMERALS

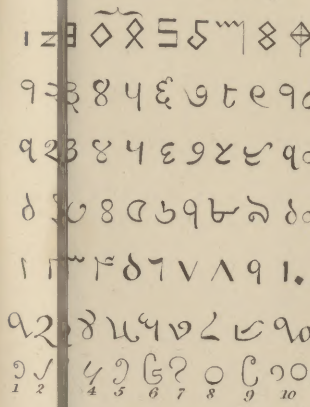


SAXON NUMERALS

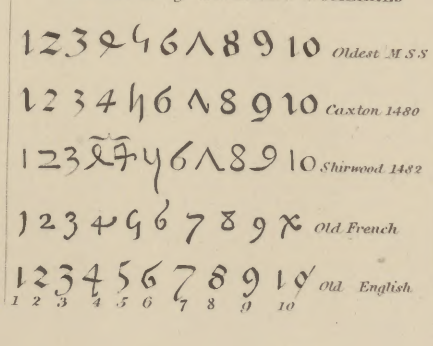


Mixture of Saxon & Arabic Numerals

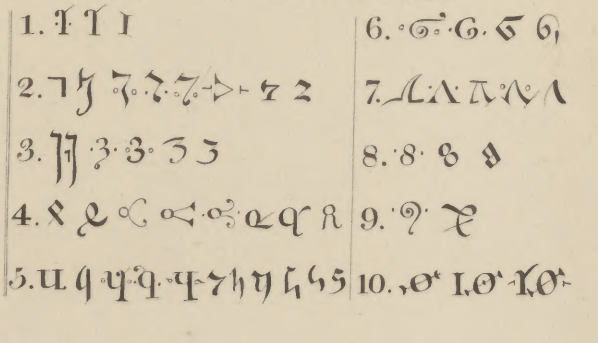




PROGRESS of EUROPEAN NUMERALS

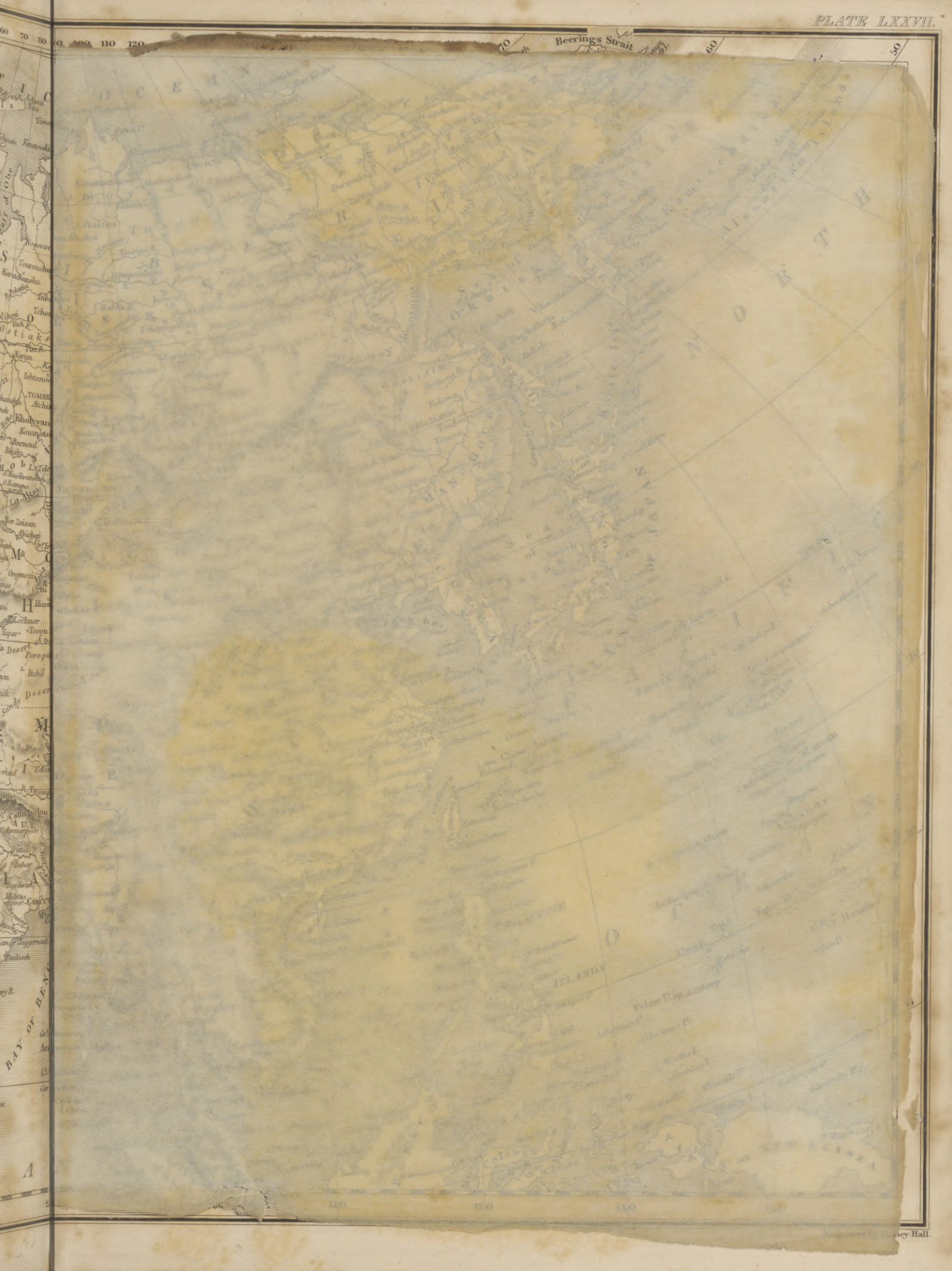


VARIATIONS of EUROPEAN NUMERALS



Engd by G. Aikman, Edinr

ASIA.
English Miles.
100 200 300 400 600 800
Arctic Circle
Tropic of Cancer
Equator
Longitude East 60 from Greenwich
ARCTIC OCEAN
EUROPE
ASIA
AFRICA
Mediterranean Sea
Black Sea
Caspian Sea
Aral Sea
Persian Gulf
Red Sea
Arabian Sea
Bay of Bengal
Libyan Desert
Arabian Desert
Sandy Desert
Desert of Kerman
Continued Desert from Mekka to Oman
Steppe of Ischim
Steppe of Kirghis Horde
Ural Mts
Caucasus Mts
Sea of Azof
White Sea
Gulf of Obi
Gulf of Cutch
Gulf of Cambay
Gulf of Manaar
Straits of Bab-el-Mandeb
Straits of Ormuz
Straits of Malacca
Straits of Gibraltar
Straits of Dardanelles
Straits of Bosphorus
Straits of Sunda
Straits of Malacca
Straits of Bab-el-Mandeb
Straits of Ormuz


Beering's Strait
70
60
50
110
120
130
140
150
TOMSK
Khokvan
Barnaul
Kouznetsk
Ishtanov
Ostiaks
Tourouchansk
Karachanska
Yakutsk
Nagasaki
Lockner
Tosson
Poro-pi
Itchô
Desert
Sandy Desert
Calcutta
Patna
Bahar
Madras
Cape Comorin
Trincomalee
Trincomalee
Tuticorin
Tuticorin
Pulicat
Pulicat
Ceylon
Ceylon
Point de Galle
Point de Galle
Colombo
Colombo
Negombo
Negombo
Chilaw
Chilaw
Mannar
Mannar
Jaffna
Jaffna
Point Pedro
Point Pedro
Trincomalee
Trincomalee
Batticaloa
Batticaloa
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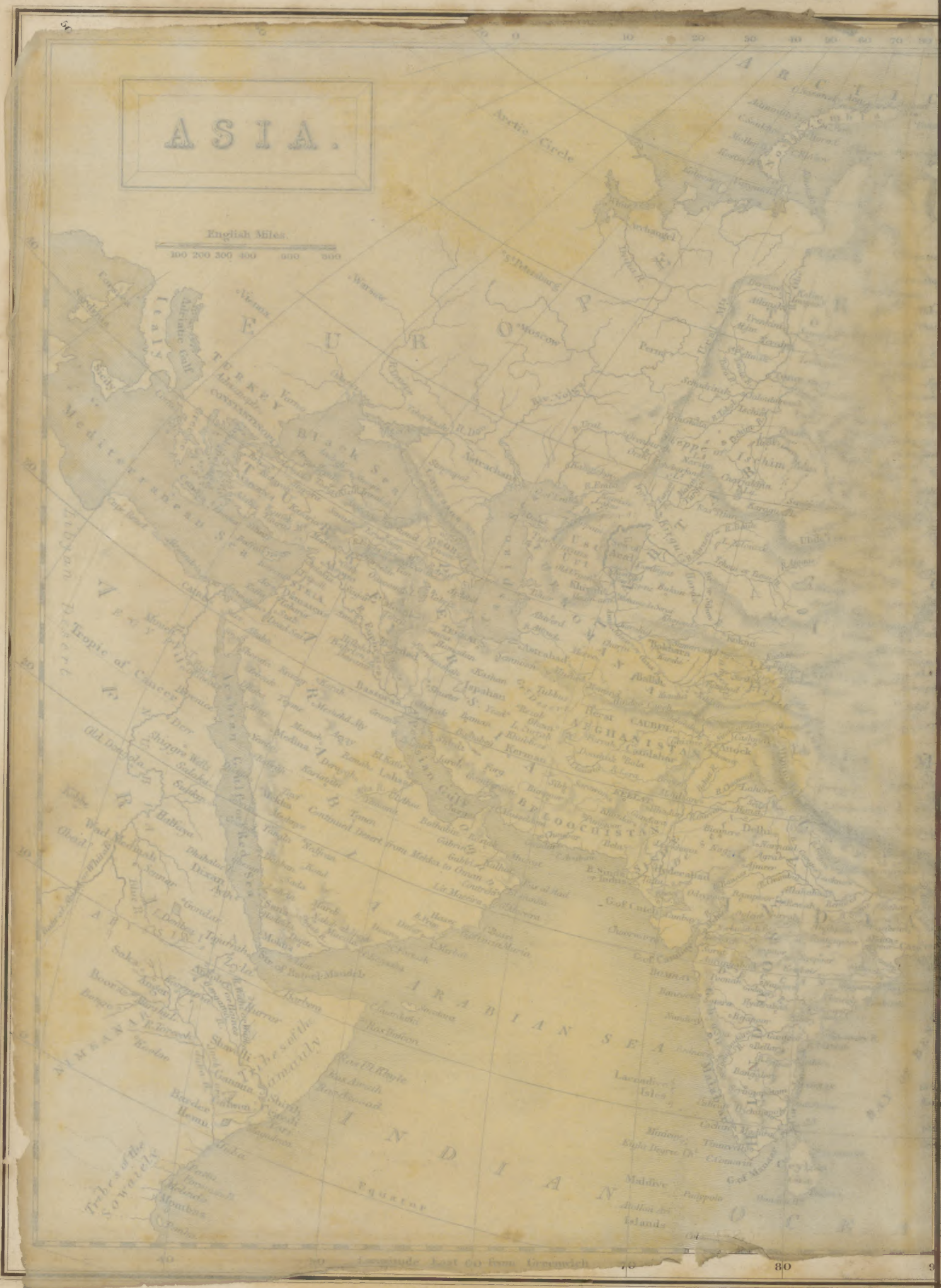
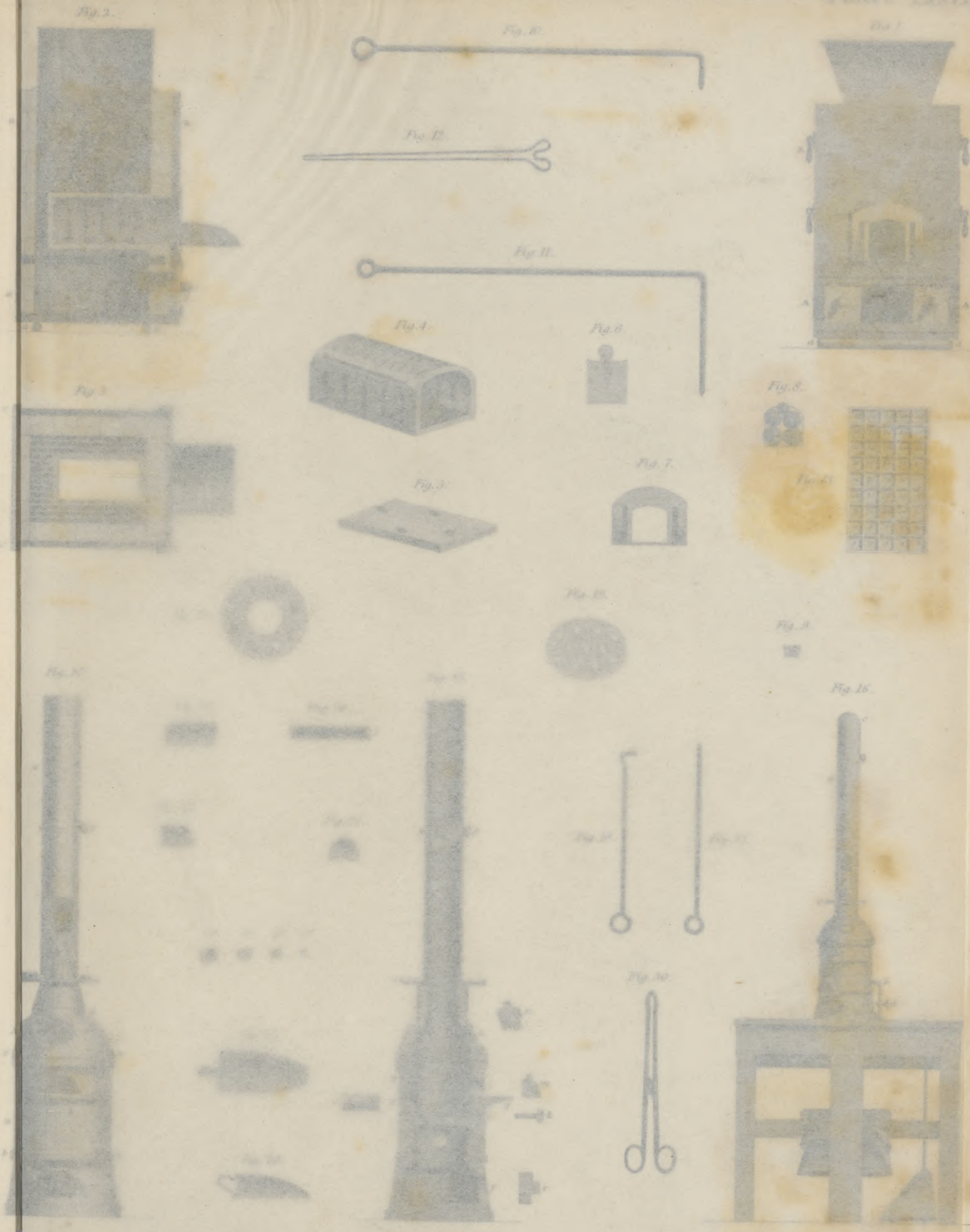
Hambantota
Galle
Galle


ASIA.
English Miles.
100 200 300 400 600 800
Arctic Circle
Tropic of Cancer
Equator
Longitude East from Greenwich
Mediterranean Sea
Black Sea
Caspian Sea
Persian Gulf
Red Sea
Arabian Sea
Indian Ocean
Aral Sea
Lake Baikal
Lake Van
Lake Urmia
Lake Tchad
Lake Victoria
Lake Tanganyika
Lake Nyassa
Lake Ngami
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Lake Winnipeg
Lake Great Bear
Lake Great Slave
Lake Athabasca
Lake Nipigon
Lake Mistassini
Lake Manitoba
Lake Winnipeg
Lake Ontario
Lake Erie
Lake Huron
Lake Michigan
Lake Superior

Beering's Strait
Sea of Okotsk
Kamtschatka
Kamtschatka or Beering
Aleoutian Islands
Kurile Islands
Sea of Japan
Sea of Sadol
Japan
Islands of Japan
Loo Choo Islands
Bonin Islands
Volcano Islands
Ladrone or Marian Islands
Philippine Islands
Celebes Sea
Sooloo Sea
Chinese Sea
Gulf of Siam
Gulf of Tonquin
Gulf of Saghalien
Strait of Malacca
Mongolian Desert
Desert of Tou
Stanovoy Mountains
Sayanians
Sayamen Mountains
Tungusi
Olensk
Yakoutsk
Okotsk
Irkoutsk
Nertchinsk
Pekin
Canton
Macao
Manila
Malacca
Singapore
Batavia
Bangkok
Ayuthia
Cambodia
Hue
Borneo
Sumatra
Celebes
Mindoro
Luzon
Mindanao
Formosa
Aroo
Ceram
Mysol
Morty
Freewill Is
Mysory I.
Exchequer Is
Admiralty Is
Two Is
Haweis Is
Egoy Is
Pelew Is
Volcano Isles
Bonin Is
Tres Columnas
Lots Wife
Sebastian Lopez
Malbrigo I.
Small I.
Tidos los Santos
St Thomas
Alessandro I.
Sulphur I.
Amsterdam I.
Kendricks I.
Dolores
Parece Vela
Vela
Urracas
Guahan
Farallones
Farallon
Grigan
Guagman
Saipan
Tinian
Anguijan
Sarigan
Pagan
Aguijan
Tanag
Amlak
Atcha
Oonalashka
Predbagenia
Amchitka
Kiska
Bendyr
Amuddak
Attoo
Agattoo
Begrings
Kamtschatka
Nalchoi Noss
Tchinsk
Kuyrong
Tawska
Yamsk
Okotsk
Ochotsk
Ochotskoi
Stanovoy Mts
Ouda
Ouskoi
Ouskoi
Ouskoi

ASSAYING.

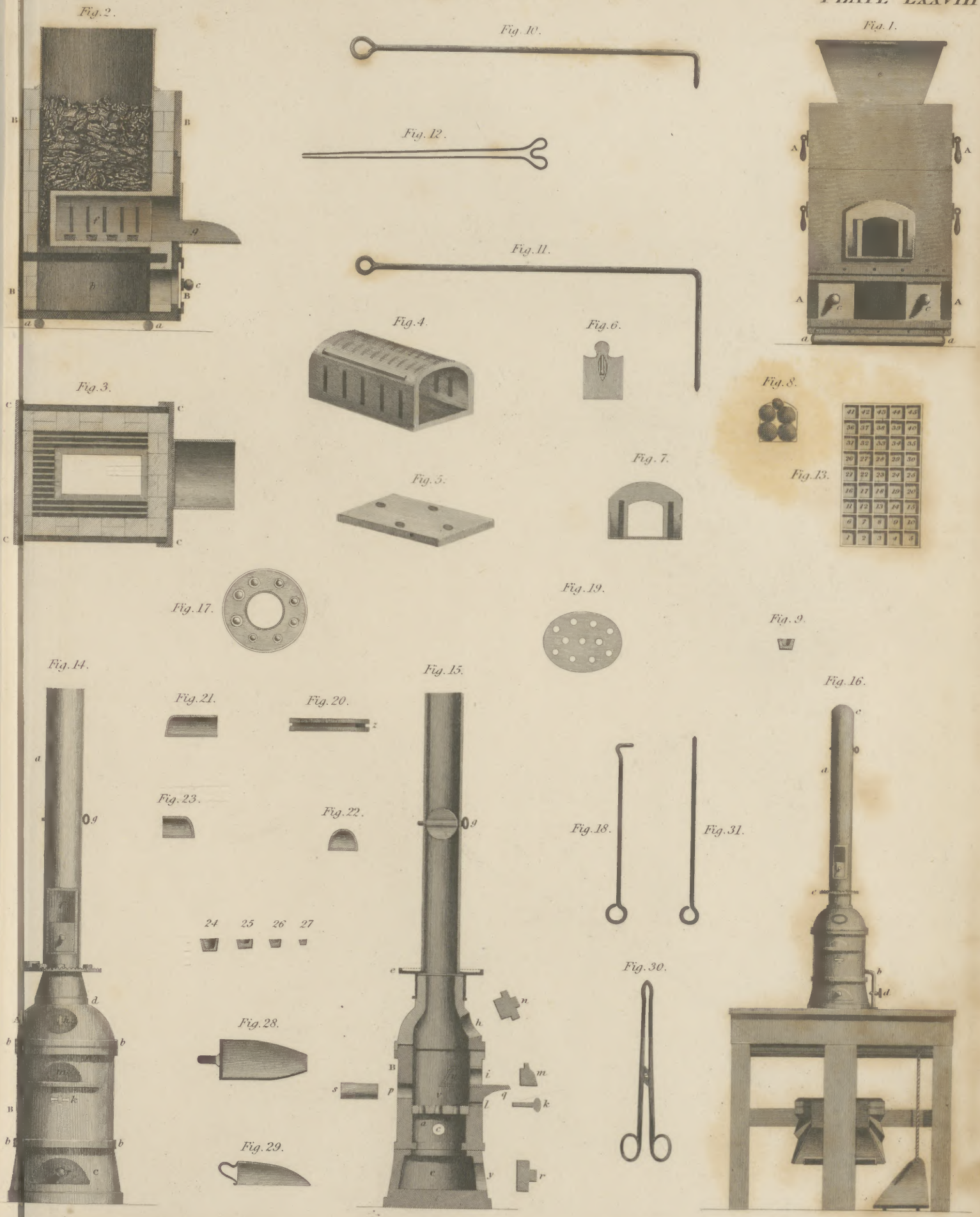
Plate [illegible]



Engd by C. Ashmore, Edinr.

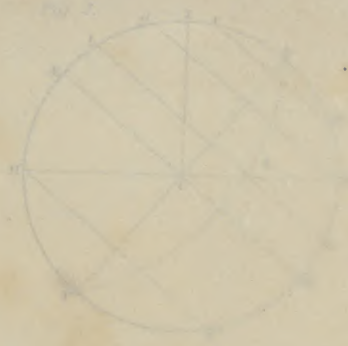
ASSAYING.

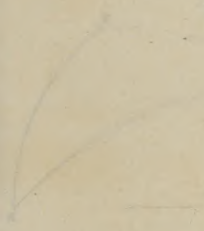
PLATE LXXVIII.

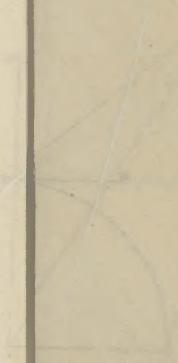


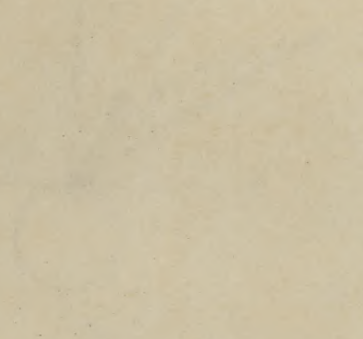
I. Farey.

Engd. by G. Aikman. Edin.r









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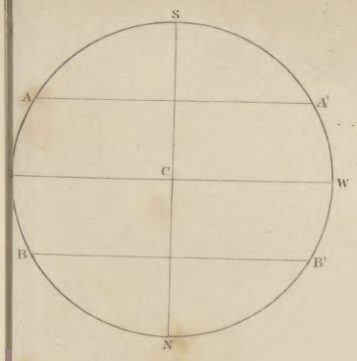

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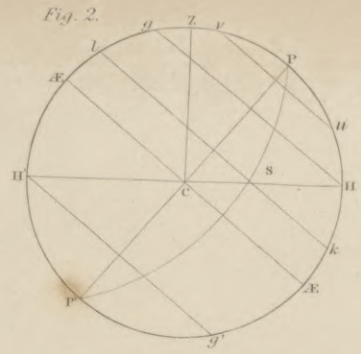

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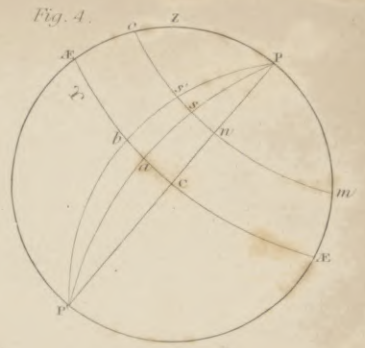

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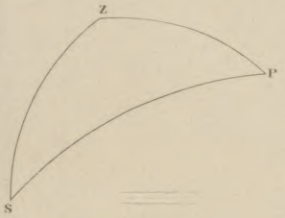

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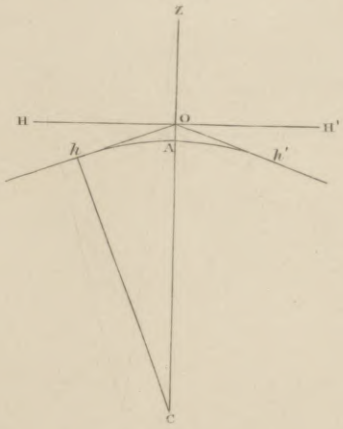

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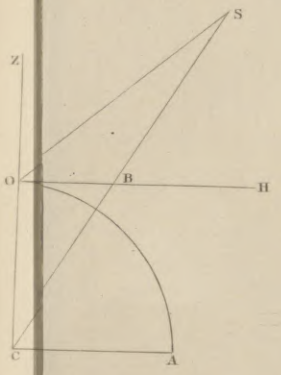

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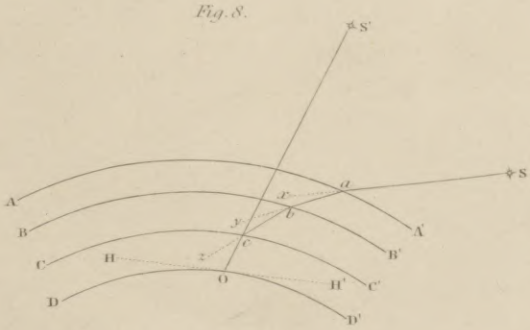

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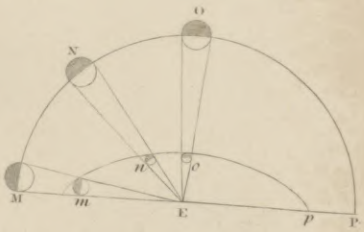

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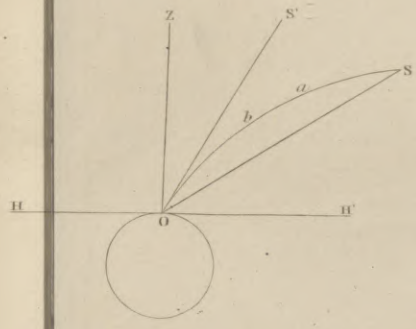

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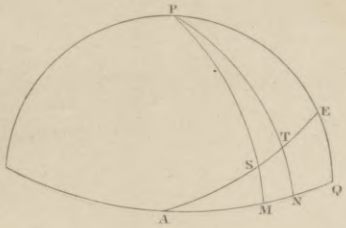

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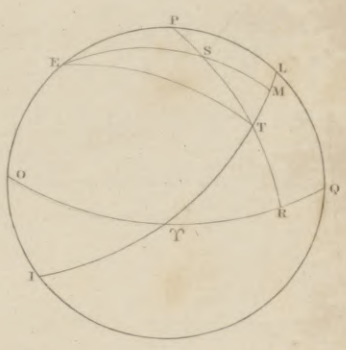

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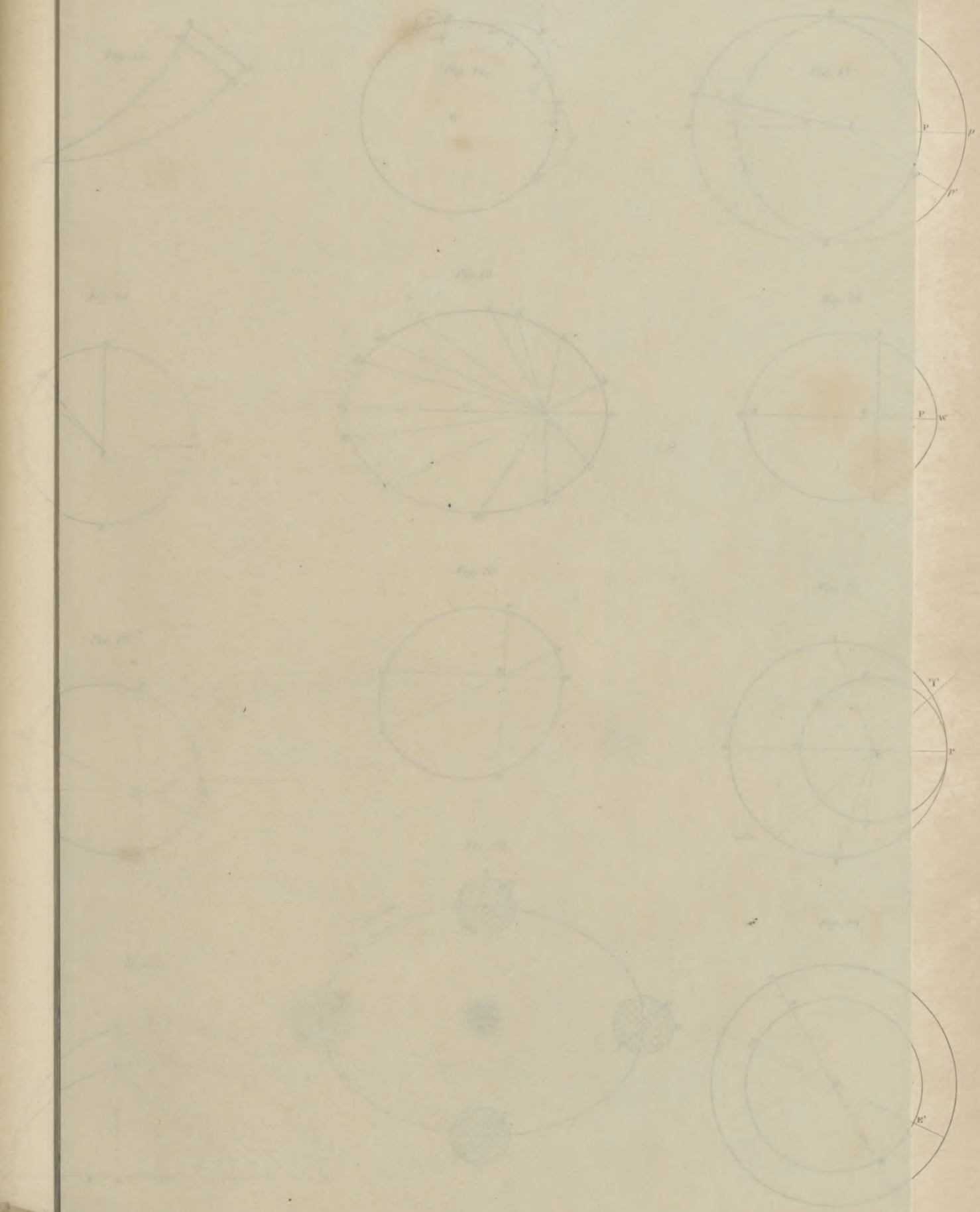

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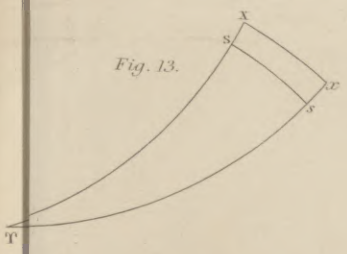

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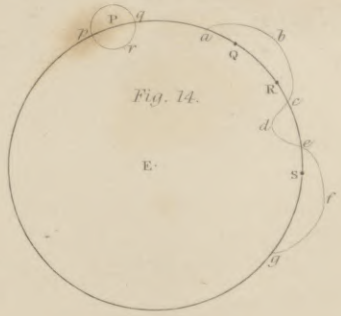

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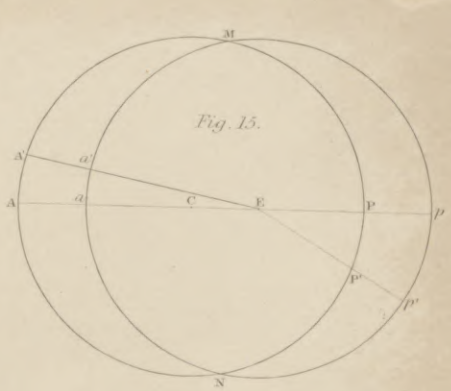

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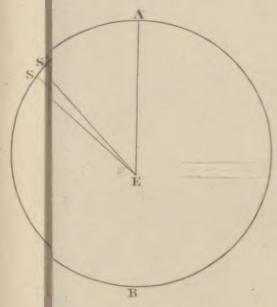

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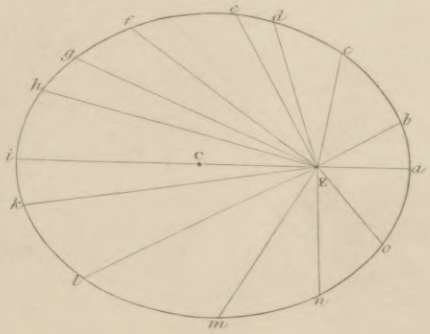

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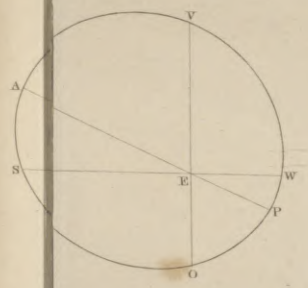

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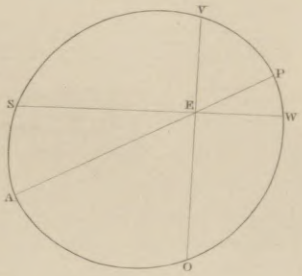

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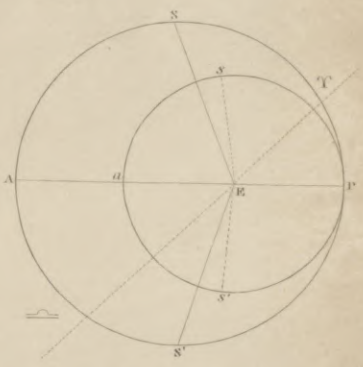

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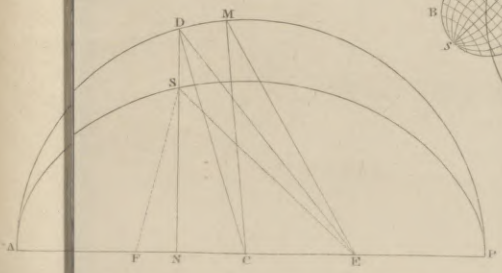

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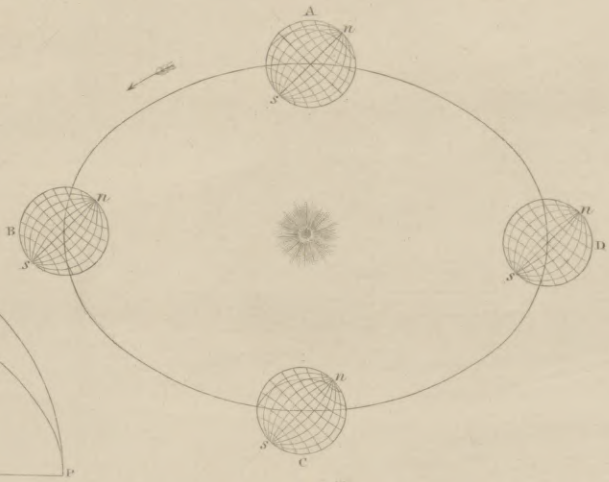

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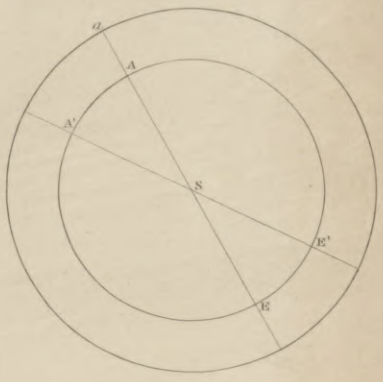

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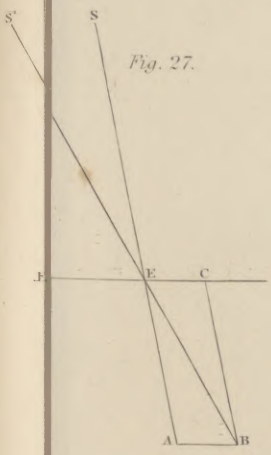

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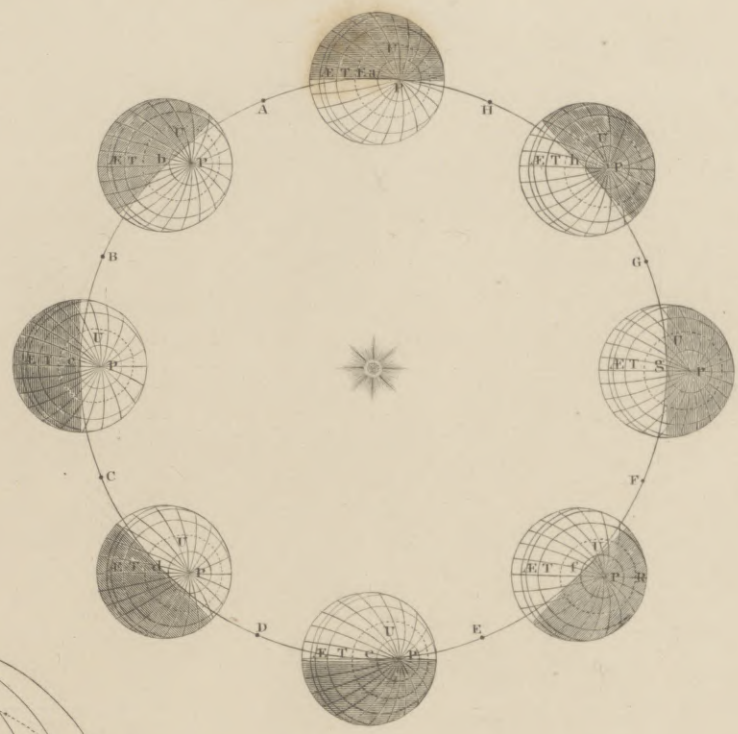

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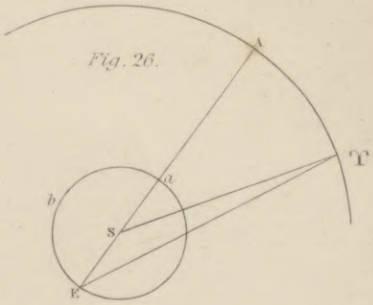

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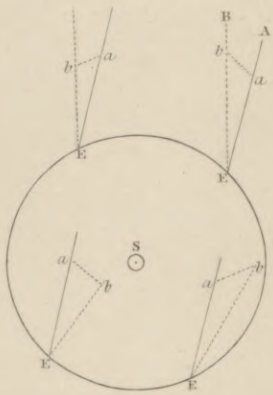

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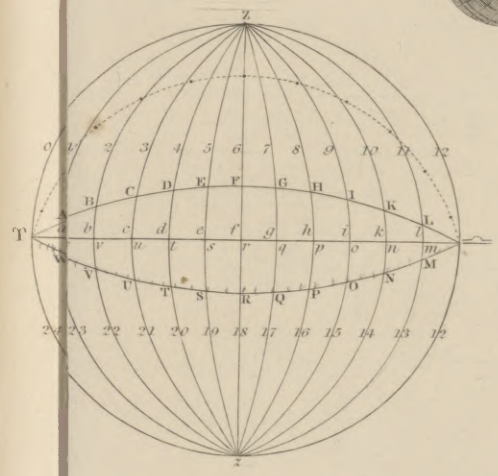

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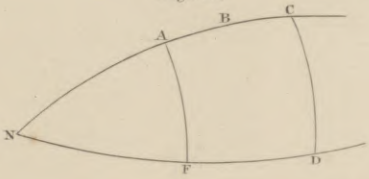

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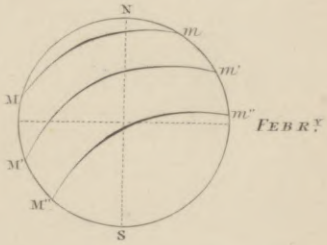

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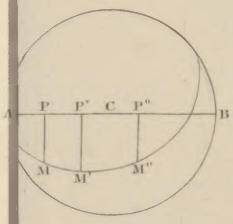

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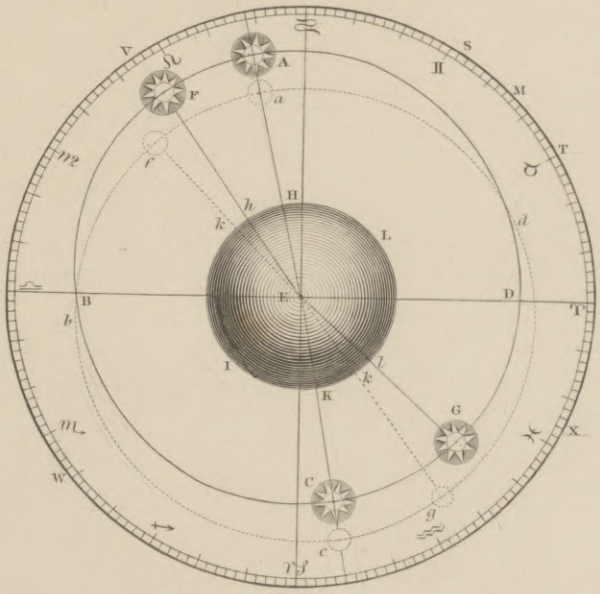

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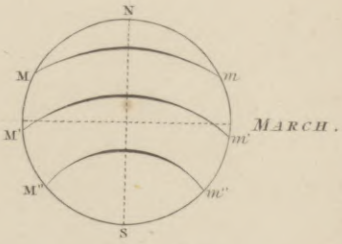

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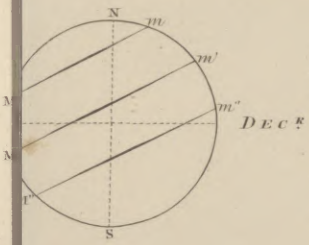

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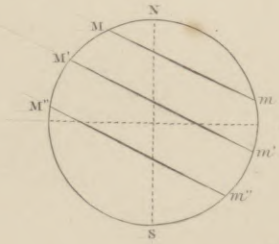

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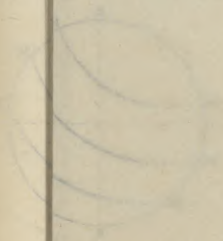

Fig. 38.

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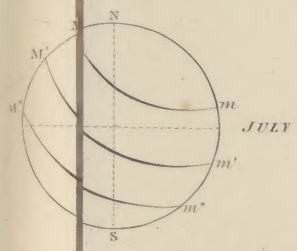

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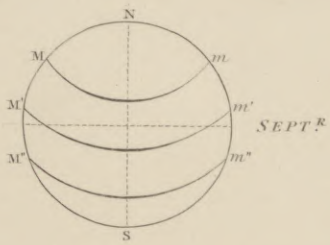

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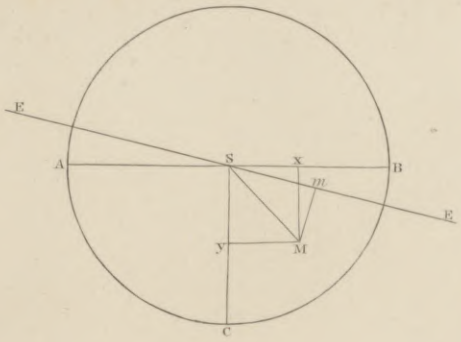

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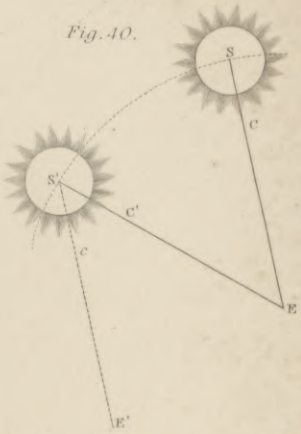

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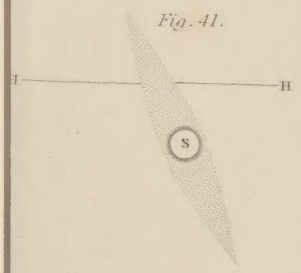

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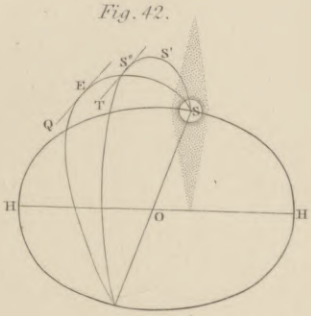

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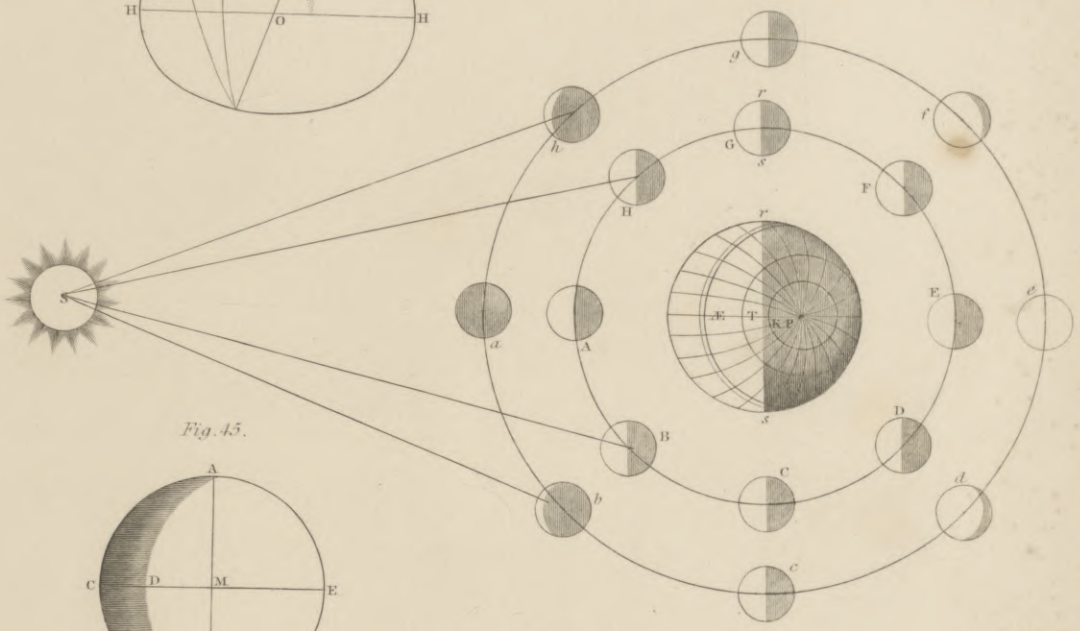

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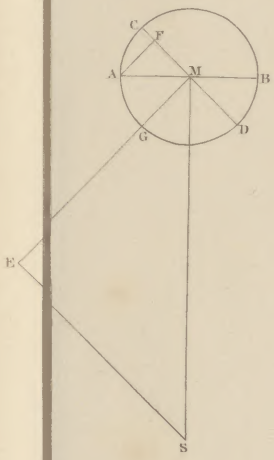

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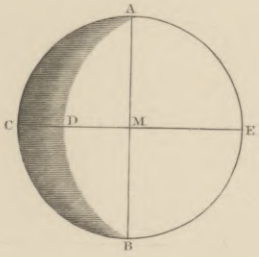

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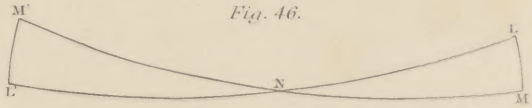

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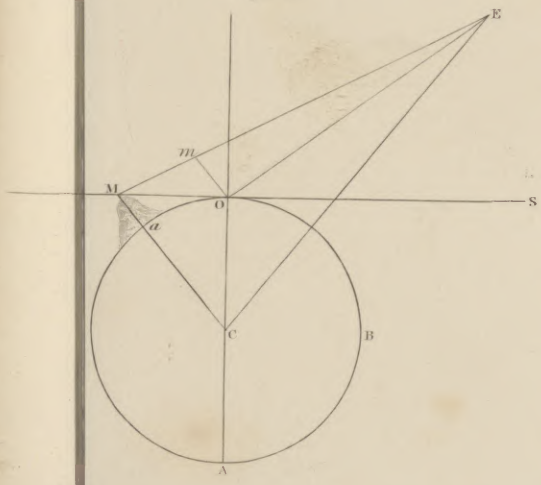

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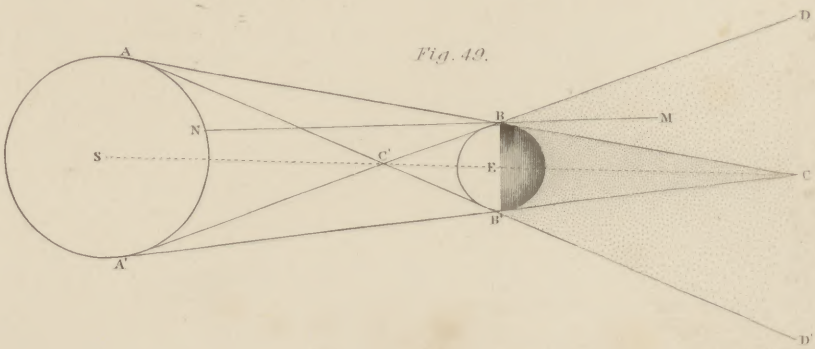

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